

Modification of the information board paradigm

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## Zusammenfassung

Das übergreifende zentrale Thema dieser Dissertation ist die Informationssuche in unterschiedlichen Kontexten und die schrittweise Modifikation von *information boards*. Informationen bilden die Grundlage für Überzeugungen, Urteile, Entscheidungen und Verhalten (Sinatra & Lombardi, 2020; Wathen & Burkell, 2002). Dafür müssen Informationen vorab verarbeitet werden – das schließt sowohl die Suche nach Informationen als auch die Evaluation der gefundenen Informationen ein (Beach & Mitchell, 1978). Heutzutage nimmt die Menge der verfügbaren Informationen ständig zu, die Relevanz und Qualität der Informationen unterscheidet sich jedoch deutlich. Daher sind nicht alle Informationen gleich wichtig. Die Relevanz kann aus verschiedenen Gründen variieren. Einer davon ist, dass die Glaubwürdigkeit der entsprechenden Quellen sehr unterschiedlich ausfällt (Collins et al., 2018; Nisbett & Ross, 1980). Aufgrund zeitlicher Einschränkungen und begrenzter kognitiver Kapazitäten können nicht alle Informationen berücksichtigt und verarbeitet werden – es muss priorisiert werden. Um zu vermeiden, dass Urteile und Entscheidungen auf der Grundlage fragwürdiger Informationen getroffen werden, müssen Informationen zur Priorisierung entsprechend ihrer Relevanz gewichtet und die Glaubwürdigkeit von Informationen und Quellen sorgfältig geprüft werden (Birnbau & Stegner, 1979; Birnbau et al., 1976; Stadtler & Bromme, 2014). Es gibt unterschiedliche Aspekte, die die Glaubwürdigkeit einer Quelle kennzeichnen. Zentral dabei ist die Expertise; damit ist gemeint, inwiefern der Quelle zugeschrieben wird, in der Lage zu sein, korrekte Informationen zu liefern, weil sie in dem betreffenden Bereich erfahren und sachkundig ist und daher als kompetent angesehen wird (Hovland & Weiss, 1951; Ohanian, 1990; Pornpitakpan, 2004). Informationen über die Quelle sind jedoch oft nicht unmittelbar zugänglich und müssen stattdessen gezielt gesucht werden (e.g., Bråten et al., 2017). Es ist daher von Bedeutung zu untersuchen, ob Menschen bei ihrer Suche nach Informationen die Quelle berücksichtigen und für die Priorisierung von Informationen nutzen. Mit einer der

gängigsten Methoden der Entscheidungsforschung – den sogenannten information boards – (cf. Payne et al., 1988) konnte die Suche von Inhalts- und Quelleninformationen jedoch nicht untersucht werden. In den Standard information boards sind Informationen über die Quellen standardmäßig gegeben und müssen nicht aktiv gesucht werden. Daher habe ich dieses Paradigma im Rahmen meiner Dissertation modifiziert und um eine aktive Suche nach Quelleninformationen ergänzt. Die Modifikationen und final modifizierten information boards habe ich in verschiedenen Studien verwendet, um ihre Nutzbarkeit empirisch zu überprüfen und den Prozess der Informationssuche genauer zu untersuchen. Dabei habe ich auch individuelle Unterschiede miteinbezogen und den Einfluss der Informationssuche auf Vorüberzeugungen näher betrachtet. Die menschliche Informationsverarbeitung ist häufig fehleranfällig (Nisbett & Ross, 1980; Tversky & Kahneman, 1974) und Menschen neigen dazu, ihre bestehenden Vorüberzeugungen zu bestätigen (Festinger, 1957, 1962; Hovland et al., 1953; Nisbett & Ross, 1980). Es kann jedoch auch vorkommen, dass neue Informationen bestehende Vorüberzeugungen beeinflussen und verändern. Aus verschiedenen Modellen zum *belief updating*, die zwar auf unterschiedlichen algebraischen Annahmen beruhen, lässt sich Folgendes ableiten: Neue Informationen werden in einer gewichteten additiven Weise mit der Vorüberzeugung bewertet. Die Stärke der neuen Informationen für eine Aktualisierung der Vorüberzeugung hängt somit von der Stärke der vorherigen Überzeugung ab. Dieser Bewertungsprozess kann also dazu führen, dass die vorherige Überzeugung zur nachfolgenden Überzeugung aktualisiert wird (Anderson, 1981; Hogarth & Einhorn, 1992; Nisbett & Ross, 1980). Generell ist eine Überzeugungsänderung wahrscheinlicher, wenn die Vorüberzeugung relativ schwach ausgeprägt ist (Wolfe & Williams, 2018). Daher ist es besonders interessant, die Veränderung von Vorüberzeugungen bei einem kontroversen Thema zu untersuchen, bei dem sich Menschen hinsichtlich ihrer Vorüberzeugungen stark voneinander unterscheiden. Ein Beispiel hierfür sind alternative Heilmethoden im Allgemeinen und Homöopathie als spezifische alternative Heilmethode. Besonders in

Deutschland wird seit vielen Jahren kontrovers darüber diskutiert. Die Diskussion bezieht sich vor allem auf die Beteiligung der Krankenkassen an den Kosten für homöopathische Mittel und Behandlungen sowie die generelle Wirksamkeit. Homöopathie basiert auf Prinzipien, die wissenschaftlichen Gesetzen widersprechen. Zusätzlich zeigen insbesondere Meta-Analysen, dass es keine Evidenz für Effekte, die über den Placebo-Effekt hinausgehen, gibt (Mathie et al., 2019; National Health and Medical Research Council, 2015). Somit ist die Wirksamkeitsdebatte aus wissenschaftlicher Perspektive geklärt. Dennoch hielten 34 % der Europäer:innen Homöopathie für wissenschaftlich (European Commission, 2005) und 55 % der Menschen in Deutschland gaben an, bereits Erfahrungen mit Homöopathie gemacht zu haben (Hillienhof, 2020). Die Beliebtheit ist ein Argument für die teilweise Übernahme der Kosten durch die Krankenkassen. Dennoch bleibt die Kostenübernahme für Behandlungen und Heilmittel, die wissenschaftlich nicht belegt sind, ein Problem. Die Debatten in diesem Themenbereich verdeutlichen die Bedeutung der Relevanz und Qualität von Informationen, die als Grundlage für Überzeugungen, Urteile und Entscheidungen stehen.

Die Dissertation ist in fünf Forschungsartikel unterteilt. Die Artikel geben die Entwicklung und Evaluation der modifizierten information boards sowie die Untersuchung von Entscheidungen, Änderungen der Vorüberzeugung und individuelle Einflussfaktoren wie folgt wieder:

**Artikel 1:** Experiment mit unbegrenzter Informationssuche und dessen Auswirkungen auf Entscheidungen mit den Standard information boards.

**Artikel 2:** Experiment mit begrenzter Informationssuche und dessen Auswirkungen auf die Änderung der Vorüberzeugungen hinsichtlich Homöopathie.

**Artikel 3:** Konzeption der modifizierten information boards sowie Pilotexperiment mit unbegrenzter Informationssuche und dessen Auswirkungen auf die Änderung der Vorüberzeugungen hinsichtlich verschiedener Gesundheits- und Bildungsthemen mit den modifizierten information boards.

**Artikel 4:** Experiment mit unbegrenzter Informationssuche und dessen Auswirkungen auf die Änderung der Vorüberzeugungen hinsichtlich Homöopathie mit den modifizierten information boards.

**Artikel 5:** Survey der Prädiktoren für den Glauben an alternative Heilmethoden allgemein sowie Homöopathie als spezifische Form.

**Artikel 1: Die Priorisierung relevanter Informationen bereitete den Probanden Schwierigkeiten und in Situationen mit hohem Konflikt zeigten sie Abweichungen vom optimalen Entscheidungsverhalten.**

Nach allen Prozesstheorien des Entscheidens wird die Qualität von Entscheidungen wesentlich von den kognitiven Fähigkeiten der Person und deren Motivation beeinflusst. Das Ziel der experimentellen Studie in Artikel 1 bestand darin, sicherzustellen, dass sowohl die kognitiven Fähigkeiten als auch die Motivation der Probanden auf einem hohen Niveau lagen, um eine hohe Qualität der getroffenen Entscheidungen zu gewährleisten. Dafür wurden die Teilnehmenden aus der hochqualifizierten Gruppe der Promovierenden, Postdoktoranden und Dozierenden an Universitäten rekrutiert. Um hohe Motivation zu erreichen, wurden die Teilnehmenden leistungskontingent vergütet. Für jede richtige Entscheidung erhielten sie einen vergleichsweise hohen Geldbetrag, der in der Summe ( $M = 25 \text{ €}$ ,  $Max = 30 \text{ €}$ ) deutlich über deren durchschnittlichem tariflichen Nettostundenlohn lag. Eine hohe Qualität der Entscheidungen konnte erreicht werden, wenn die Wahrscheinlichkeiten in der probabilistischen Entscheidungsaufgabe effektiv genutzt wurden, um relevante gegenüber weniger relevanten Informationen zu priorisieren. Zur Untersuchung wurde eine Variante des Standardparadigmas für probabilistische Inferenz der Entscheidungsforschung genutzt. Hierfür fanden bereits vorherige Studien interindividuelle Varianz in Bezug auf die Informationssuche und Entscheidungskompetenz. Es wurde zusätzlich untersucht, ob die Unterschiede hinsichtlich der Entscheidungsqualität durch die Statistik- und

Methodenkompetenz der Teilnehmenden erklärt werden können. Generell zeigten die Ergebnisse, dass die Teilnehmenden unabhängig ihrer Statistik- und Methodenkompetenz Schwierigkeiten hatten, relevante Informationen konstant zu priorisieren. Sie suchten mehr Informationen als nach dem Ansatz des adaptiven Entscheidens notwendig gewesen wären. Dennoch trafen sie in eindeutigen Entscheidungssituationen größtenteils optimale Entscheidungen, was zu hohen finanziellen Gewinnen führte. Sobald die Entscheidungssituationen konfligierende Informationen enthielten, führte die übermäßige Suche weniger relevanter Informationen jedoch zu Abweichungen im Entscheidungsverhalten. Die Teilnehmenden trafen dann schlechtere Entscheidungen und erzielten damit weniger finanzielle Gewinne.

Die gefundenen Abweichungen im Verhalten führten zu den Studien der anderen Artikel. Wenn sogar Probanden mit hohen kognitiven Fähigkeiten und hoher Motivation Schwierigkeiten haben, relevante Informationen konstant zu priorisieren, ist es wichtig herauszufinden, wie Individuen bei der Priorisierung unterstützt werden können. In einem ersten Schritt wurden die Quelleninformationen angepasst und von einer probabilistischen hin zu einer inhaltlichen Information geändert. Zudem wurde die Informationssuche limitiert.

**Artikel 2: Bei einer limitierten Informationssuche gelang es den Probanden, die Informationen von Quellen mit hoher Expertise zu priorisieren.**

Artikel 2 behandelt, wie Menschen in Bezug zu einem kontroversen Thema – der Homöopathie – Informationen suchen. Viele Menschen glauben an die Wirksamkeit der Homöopathie zur Behandlung gesundheitlicher Probleme, obwohl wissenschaftlich belegt ist, dass deren Wirkung nicht über Placebo Effekte hinaus geht. Aus verschiedenen Ansätzen, sowohl aus der Entscheidungsforschung als auch aus Theorien der Kognitions- und Sozialpsychologie, kann abgeleitet werden, dass Menschen unterschiedliche Strategien zur Suche von Informationen nutzen. Darüber hinaus lassen sich aus den verschiedenen Modellen zum belief updating Erwartungen ableiten, die den Einfluss der gesuchten Informationen auf



die Vorüberzeugung betreffen. In dieser experimentellen Studie wurde untersucht, welche Information in Form von Argumenten gesucht wird und wie die Präsentation eines Arguments die Vorüberzeugung ändert. Die Suche war limitiert, sodass die Teilnehmenden eines von vier Argumenten zum kontrovers diskutierten Thema der Wirksamkeit von Homöopathie suchen durften. Die Argumente variierten hinsichtlich der Expertise der Quelle und der Richtung (pro vs. contra). Die Ergebnisse zeigten, dass Argumente von Expert:innen priorisiert wurden. Der Befund wurde jedoch von der Intention zukünftig homöopathische Mittel einzunehmen beeinflusst. Überraschenderweise hatte die Richtung der Argumente keinen Einfluss auf das Suchverhalten. Die Analyse der Überzeugungen vor und nach der Informationssuche zeigte entgegen der Erwartungen keinen signifikanten Unterschied durch die Richtung des gelesenen Arguments. Allerdings beeinflusste die Intention in Zukunft homöopathische Mittel einzunehmen die Überzeugungen – Teilnehmende, die beabsichtigten zukünftig homöopathische Mittel einzunehmen, stimmten nach der Informationssuche stärker zu, dass Homöopathie nur aufgrund des Placebo-Effekts wirksam ist, als vor der Informationssuche.

In einem nächsten Schritt sollte untersucht werden, ob Individuen die Informationen über die Quellen berücksichtigen, auch wenn diese nicht direkt bereitgestellt werden, sondern aktiv gesucht werden müssen und die Informationssuche nicht mehr limitiert ist, sodass generell mehr Informationen zur Verfügung stehen.

**Artikel 3: Die strukturelle Erweiterung der information boards durch die Integration einer aktiven Suche nach Quelleninformationen war erfolgreich, da Probanden sowohl Inhalts- als auch Quelleninformationen bei ihrer Suche berücksichtigten.**

Artikel 3 legt die Entwicklung und Struktur der modifizierten information boards dar und beschreibt die erste empirische Studie zur Nutzbarkeit der modifizierten information boards. In der Entscheidungsforschung wurde eine zentrale Komponente der Suche bisher fast völlig vernachlässigt: Die Suche nach Informationen über die Quellen. Die information boards, die standardmäßig in der Entscheidungsforschung verwendet werden, schließen eine

Informationssuche nach Quelleninformationen nicht ein, weil diese Informationen üblicherweise direkt bereitgestellt werden. Daher wurde das Paradigma um die Komponente der aktiven Suche nach Quelleninformationen strukturell erweitert. Die modifizierten, innovativen information boards wurden zu verschiedenen Themen aus zwei Domänen (Gesundheit und Bildung) sorgfältig und erfolgreich vorgetestet. Die Ergebnisse zeigten, dass die Teilnehmenden bei ihrer Suche die Informationen über die Quellen berücksichtigten. Mit der strukturellen Erweiterung des Paradigmas kann also das Suchverhalten hinsichtlich Inhalts- und Quelleninformationen gleichzeitig untersucht werden. Die Modifikation und empirischen Studie zur Nutzbarkeit stellen zwei wichtige Schritte dar, um in Folgestudien das Suchverhalten über alle strukturell relevanten Dimensionen zu erforschen.

In der nachfolgenden Studie wurden die Erkenntnisse aus den vorherigen Studien zusammengeführt. Es sollte untersucht werden, ob die inhaltlichen Informationen zu den Quellen weiterhin dazu führen, dass die Informationen von verlässlicheren Quellen priorisiert werden, selbst wenn die Informationen über die Quellen aktiv gesucht werden müssen und die Informationssuche nicht limitiert ist.

**Artikel 4: Wenn Informationen über die Quellen aktiv gesucht werden müssen, suchten die Probanden diese zuerst.**

Artikel 4 präsentiert eine experimentelle Studie, in der die Informationssuche mit den modifizierten information boards weiter untersucht wurde. Im Gegensatz zur Pilotstudie lag der Fokus in dieser Studie nur auf einem Thema aus der Domäne Gesundheit, nämlich auf der Homöopathie. Den Probanden wurden jeweils zwei modifizierte information boards präsentiert – einerseits zur Diskussion über die Homöopathie als Krankenkassenleistung, andererseits zur Diskussion über die Wirksamkeit von Homöopathie. Innerhalb der information boards wurden wieder sowohl Inhalts- als auch Quelleninformationen variiert und zur aktiven Suche angeboten. Das ermöglicht es in dieser Studie, das Suchverhalten über die strukturell relevanten Dimensionen zu erforschen. Aus den bekannten Strategien der

Entscheidungsforschung und Theorien der Kognitions- und Sozialpsychologie wurden Erwartungen über den Verlauf der Suche abgeleitet. Zudem wurde erneut der Einfluss der Informationssuche auf die Vorüberzeugung untersucht; hierzu konnten aus den Modellen zum belief updating Erwartungen zu Veränderungen der Vorüberzeugungen abgeleitet werden. Die Ergebnisse zeigten, dass die Teilnehmenden wie erwartet die Quelle der Information für den Beginn der Informationssuche priorisierten, indem sie mit einer Information zur Expertise der Quelle begannen. Sie priorisierten jedoch keine Informationen hinsichtlich der Suchmenge im Verlauf der Suche: Die Teilnehmenden fokussierten weder auf Informationen von Expert:innen noch auf Informationen, die ihre Vorüberzeugungen bestätigten. Stattdessen suchten sie fast alle verfügbaren Informationen. Abhängig des information boards (Krankenkassenleistung vs. Wirksamkeit) änderten 25 % bzw. 30 % der Teilnehmenden ihre Vorüberzeugung.

In den Studien 2-4 lag der Fokus einerseits auf der Informationssuche, andererseits auf den Vorüberzeugungen der Probanden und deren Veränderungen durch die Suche nach neuen Informationen. Es zeigte sich, dass nur ein Teil der Teilnehmenden ihre Vorüberzeugungen im Kontext der Homöopathie durch die Informationssuche änderte. In dem Zusammenhang war es interessant näher zu untersuchen, welche Faktoren den Glauben an Homöopathie und Komplementär- und Alternativmedizin erklären können.

#### **Artikel 5: Individuelle Faktoren können Unterschiede im Glauben an Komplementär- und Alternativmedizin sowie Homöopathie erklären.**

Der Survey in Artikel 5 prüft, welche kognitiven und persönlichkeitsbezogenen Faktoren Unterschiede im Glauben an Komplementär- und Alternativmedizin allgemein sowie an Homöopathie als spezifische Form erklären können. Verschiedene psychologische Modelle und Theorien zeigen, dass *beliefs* (Glaube/Vorüberzeugung) maßgeblich beeinflussen, wie die Intention ein bestimmtes Verhalten zu zeigen, ausfällt. Das Verhalten kann die Suche nach Informationen oder die Einnahme von Heilmitteln sein. Laut der

Theorien und Modelle liegen hinter den beliefs spezifische individuelle und soziale Faktoren, die wiederum Einfluss darauf nehmen, wie die beliefs ausgeprägt sind. In vorherigen Studien wurde eine Vielzahl möglicher Prädiktoren für den Glauben an Komplementär- und Alternativmedizin allgemein sowie an Homöopathie als spezifische Form herausgefunden. Allerdings überprüften die Autor:innen dieser Studien die Faktoren eher partikular in kleinen Modellen mit einer Auswahl weniger Prädiktoren. Dadurch bleibt die relative Vorhersagekraft der einzelnen Prädiktoren unbekannt. Diese Lücke in der Literatur sollte durch diese Studie geschlossen werden, indem die Robustheit von 21 Prädiktoren untersucht wurde, wenn diese gemeinsam in einem Modell analysiert wurden. Die Prädiktoren wurden aus den bisherigen Studien und Pretests entnommen. Mit diesem Vorgehen sollten Einblicke in die zentralen Determinanten der Überzeugungen erlangt werden. Die Ergebnisse zeigten, dass eine Kombination von fünf Prädiktoren 20 % der Varianz des Glaubens an Komplementär- und Alternativmedizin erklärte. Etwa 21 % der Varianz des Glaubens an Homöopathie konnten durch acht Prädiktoren – zum Teil dieselben, zum Teil andere als beim Glauben an Komplementär- und Alternativmedizin – erklärt werden. Es wird deutlich, dass Individuen, die an Komplementär- und Alternativmedizin und Homöopathie glauben, bestimmte Unterschiede zeigen. Dennoch ist ihnen gemeinsam, dass sie gewisse kognitive Verzerrungen und individuelle Faktoren haben, die dazu führen, dass sie die Welt anders wahrnehmen. Das kann dazu führen, auch neue Informationen anders zu bewerten.

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– African proverb

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## Overview

During my PhD, I investigated the process of information search in different contexts and its influences on decision making and beliefs as well as effects of different individual factors on information search and beliefs. To do so, I modified the standard information boards used in judgment and decision making research. This research resulted in five articles on the topic. The overall research questions were: How do people search information in different contexts? Are they able to prioritize the most relevant information independent of paradigm? Does information search influence prior beliefs in that beliefs change after information search? Do individual factors (i.e., prior beliefs, behavior intentions) influence information search? Which individual factors can explain questionable beliefs?

The following section provides a brief overview of the main information, i.e., purpose and results. An overview of the design and variables included in each article of this dissertation is displayed in Table 1.

### Article 1

Aßmann, L., Betsch, T., Lang, A., & Lindow, S. (2022). When even the smartest fail to prioritise: overuse of information can decrease decision accuracy. *Journal of Cognitive Psychology*, 34(5), 675–690, <https://doi.org/10.1080/20445911.2022.2055560>

Article 1 presents a preregistered experiment on unlimited information search and decision making with the standard probabilistic inference paradigm from judgment and decision making research – so-called information boards. The study was conducted to investigate whether individuals with high abilities and high motivation prioritize the most relevant information according to their probabilistic weight to reach high decision accuracy. Results demonstrated that even participants with high abilities and high motivation had difficulty in consistently prioritizing relevant information and overused information. Nevertheless, they achieved high decision accuracy in explicit decision contexts. However, they showed deviations from adaptive decision making when information was conflicting.

The experiment was presented and discussed at the 64<sup>th</sup> Conference of Experimental Psychologists (TeaP, 2022, online) and the 28<sup>th</sup> Subjective Probability, Utility and Decision Making Conference (SPUDM, 2021, online). The experiment was published as a research article in an international, peer-reviewed, academic journal.

## **Article 2**

Aßmann, L. & Betsch, T. (2023). *Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations*. Manuscript submitted for publication.

Article 2 discusses a preregistered online experiment on limited information search in relation to the controversial topic of homeopathy. The study was performed to examine both information search and the influence of information exposure on prior beliefs. Results showed that participants prioritized arguments from expert sources. Such prioritization was, however, influenced by participants' future intake intentions, which, in turn, also influenced participants' prior beliefs.

The experiment was presented and discussed at the Annual Meeting of the Society for Judgment and Decision Making (SJDM Conference, 2022, online). The article was submitted to an international, peer-reviewed, academic journal.

## **Article 3**

Aßmann, L., Futterleib, H., Betsch, T., Thomm, E., & Bauer, J. (2021). *How do people search information on content and sources? Integrating source search in information boards*. PsyArXiv. <https://doi.org/10.31234/osf.io/jydnv>

Article 3 introduces the modified information boards and an empirical pilot experiment for the innovative paradigm. The modification entails a structural expansion of the standard information boards by integrating an active search for source information. The empirical evaluation confirmed the usefulness of the modified information boards, since results showed that participants considered source information even when it had to be actively

searched. Thus, the modified information boards can be used to investigate information search of content and source information simultaneously.

The experiment was presented and discussed at the 28<sup>th</sup> Subjective Probability, Utility and Decision Making Conference (SPUDM, 2021, online). The article is published on *PsyArXiv*, a preprint repository for the psychological sciences maintained by the Society for the Improvement of Psychological Science (SIPS).

#### **Article 4**

Aßmann, L. (2023). *You ask the experts – but then you don't listen to them: Prioritization of source expertise for search start but not for search amount*. Manuscript submitted for publication.

Article 4 further highlights information search with the modified information boards. I conducted a preregistered online experiment that focused on the information search in relation to the controversial topic of homeopathy using two different, modified information boards. Additionally, I examined how beliefs change due to information search. Results showed that participants prioritized source information for search start but again overused information by focusing on neither expert information nor belief-confirming information during their search. Between one-third and one-quarter of participants changed their beliefs after information search depending on the information board.

The experiment was submitted as a research article to an international, peer-reviewed, academic journal.

#### **Article 5**

Aßmann, L. & Betsch, T. (2023). Medical decision making beyond evidence: Correlates of belief in complementary and alternative medicine (CAM) and homeopathy. *PLOS ONE*, *18*(4), e0284383. <https://doi.org/10.1371/journal.pone.0284383>

Article 5 focuses on cognitive as well as personality factors and their explanatory power for differences in belief in CAM and belief in homeopathy. The robustness of 21

predictor variables was explored to obtain insights into the key determinants. We conducted a survey and results showed that a combination of cognitive and personality factors explained 20% of variance in belief in CAM and 21% of variance in belief in homeopathy. Some predictors could explain both forms of beliefs, whereas others explained only one or the other. Predictors suggested that individuals appear to hold a different world view and demonstrate certain cognitive biases.

The results were presented and discussed at the 36<sup>th</sup> Annual Conference of the European Health Psychology Society (EHPS Conference, 2022, Bratislava, Slovakia). The study was published as a research article in an international, peer-reviewed, academic journal.

**Table 1**

Overview of Design and Variables of the Articles Included in the Dissertation

Article	Sample	<i>N</i>	Setting	Information Search	Decision	Judgment	Status
1	PhD students, postdocs and lecturers	49	laboratory	x	x	-	published (journal)
2	heterogeneous, nonstudent sample (Prolific)	201 (study) + 80 (pretest)	online	x	-	x	submitted
3	student sample (University of Erfurt)	29	laboratory	x	-	x	published (preprint repository)
4	heterogeneous, nonstudent sample (Prolific)	299	online	x	-	x	submitted
5	heterogeneous, nonstudent and student sample (participant pool, University of Hagen)	599	online	-	-	-	published (journal)
		$\Sigma$ 1,257					

### Author Contributions

<b>Article 1</b>	<p>Aßmann, L., Betsch, T., Lang, A., &amp; Lindow, S. (2022). When even the smartest fail to prioritise: overuse of information can decrease decision accuracy. <i>Journal of Cognitive Psychology</i>, 34(5), 675–690.  <a href="https://doi.org/10.1080/20445911.2022.2055560">https://doi.org/10.1080/20445911.2022.2055560</a>            Conceived and designed the experiments: LA, TB, AL, SL            Performed the experiment &amp; analyzed the data: LA            Wrote the paper: LA            Approved the final draft: LA, TB, AL, SL</p>
<b>Article 2</b>	<p>Aßmann, L. &amp; Betsch, T. (2023). <i>Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations</i>. Manuscript submitted for publication.            Conceived and designed the experiments: LA, TB            Performed the experiment &amp; analyzed the data: LA            Wrote the paper: LA            Approved the final draft: LA, TB</p>
<b>Article 3</b>	<p>Aßmann, L., Futterleib, H., Betsch, T., Thomm, E., &amp; Bauer, J. (2021). <i>How do people search information on content and sources? Integrating source search in information boards</i>. <a href="https://doi.org/10.31234/osf.io/jydnv">https://doi.org/10.31234/osf.io/jydnv</a>            Conceived and designed the experiments: LA, HF, TB, ET, JB            Performed the experiment &amp; analyzed the data: LA, HF            Wrote the paper: LA            Approved the final draft: LA, HF, TB, ET, JB</p>
<b>Article 4</b>	<p>Aßmann, L. (2023). <i>You ask the experts – but then you don't listen to them: Prioritization of source expertise for search start but not for search amount</i>. Manuscript submitted for publication.</p>
<b>Article 5</b>	<p>Aßmann, L. &amp; Betsch, T. (2023). Medical decision making beyond evidence: Correlates of belief in complementary and alternative medicine (CAM) and homeopathy. <i>PLOS ONE</i>, 18(4), e0284383.  <a href="https://doi.org/10.1371/journal.pone.0284383">https://doi.org/10.1371/journal.pone.0284383</a>            Conceived and designed the experiments: LA, TB            Performed the experiment &amp; analyzed the data: LA            Wrote the paper: LA            Approved the final draft: LA, TB</p>

#### Other published articles that are not included in the dissertation:

Betsch, T., Aßmann, L., & Glöckner, A. (2020). Paranormal beliefs and individual differences: Story seeking without reasoned review. *Heliyon*, 6(6), e04259.

<https://doi.org/10.1016/j.heliyon.2020.e04259> (peer-reviewed journal)

Lindow, S. & Aßmann, L. (2022). Wonach Kinder entscheiden. *KSA (Kinderschutz Aktuell – Die Zeitschrift des Kinderschutzbundes)* 3.2022, 12–15. (applied magazine)

Lindow, S., Aßmann, L. & Breuer, L. (2023). In was für einer Welt werden unsere Kinder leben? *Praxis Schulpsychologie*, 35, 13. (applied magazine)

# **General Introduction**

In recent times, the world is confronted with many crises. Climate change and the COVID-19 pandemic are only two examples of the challenges we are faced with today. Such crises require decisions to be made. Ideally, those decisions lead to overcoming the crises. Often there are different decision makers, for example politicians, the public, or groups of individuals. When evidence is available, this should be the normative guideline for judgments and decision making. However, those crises are characterized by high uncertainty. People strive to reduce uncertainty – for example by searching for explanatory information (Brashers et al., 2002). This information must be reliable and provided by credible sources. Nevertheless, questionable and false information are also circulating (Lewandowsky et al., 2012). The use of such information can often lead to the development of different beliefs. Holding irrational beliefs and making inferior decisions due to a questionable information basis can have severe consequences for the individual and the public, such as economic loss, health-related issues, or inaction (Kerr & Wilson, 2018). Additionally, it might result in heated discussions both in the private sphere and in society as a whole. This could be observed well in the last years – especially with regard to the pandemic, but also in relation to the climate crisis. Yet, the need for reliable information as a decision and belief basis applies not only to major social issues but also at the individual level, e.g., in the health context. Individuals are increasingly involved in medical and health-related decision making (Makoul & Clayman, 2006; Miller & Reihlen, 2023; Stiggelbout et al., 2015). Medical decision making, in particular, involves decisions that can result in either benefit or harm (Barrett, 2012). Thus, the ability to make informed decisions requires an adequate processing and weighting of (probabilistic) information as well as an evaluation of sources. There are many possibilities to acquire health information, e.g., from health care professionals, in books or on the internet. The latter has become one of the most popular media due to technical advances in the last decade. Most people unfamiliar with a topic turn to the internet to search for information (cf. Taddicken, 2013), which also applies to health topics (Bujnowska-Fedak et



al., 2019) – between 66 % and 77 % of Germans (Horch, 2021; Techniker Krankenkasse, 2018) have previously accessed health information online. Even if information is easily accessible online, its quality varies greatly – thus, it is not consistently reliable (Daraz et al., 2019). Finding reliable information online can be challenging, since there are no gatekeepers to ensure information quality (e.g., Scharrer & Salmerón, 2016). Credible information is just as easily accessed as mis- and disinformation (Lewandowsky et al., 2012). Thus, individuals must be careful selecting and evaluating information to avoid falling for misinformation and deception (Sinatra & Lombardi, 2020; Sperber et al., 2010). For example, health related information is provided not only by experts but also by other laypersons. Especially online, there is a vast number of health websites, blogs, and discussion boards where anyone can post information and share their experiences, which can influence the reader's judgments and decisions (C. Betsch et al., 2011; Haase et al., 2015).

### **Decision Making and Judgment Formation**

Decisions are part of our everyday lives. An individual makes approximately 20,000 automatic decisions daily (Pöppel, 2008) in addition to the deliberate decisions that they also make each day. How do people decide? Do they make rational decisions? How do people search information? How do they integrate information to come to a judgment? Such questions have been addressed in the field of judgment and decision making for decades (e.g., Edwards, 1954; Einhorn & Hogarth, 1981; Goldstein & Hogarth, 1997; Kahneman & Tversky, 1979; Neumann & Morgenstern, 1944; Payne et al., 1988, 1993; Simon, 1955; Tversky & Kahneman, 1974). Decision making means choosing between different options or behavior (intentions) whereas judgments can be interpreted as a reflection of an individual's "state of mind about a matter either of fact (prediction or estimation) or evaluation (preference or opinion)" (Goldstein & Hogarth, 1997).

## **Information Search**

Generally, information forms the basis for judgment and decision making, problem solving, belief and attitude change as well as behavior (Sinatra & Lombardi, 2020). In this dissertation, I focus on information search for judgment and decision making. Additionally, I investigate the influence of information search on belief change.

Before a judgment is formed or a decision is made, one typically needs to process information – which includes the search and evaluation of information (Beach & Mitchell, 1978). Sometimes the individual's role is rather passive, since information is automatically processed. However, in most situations, the individual needs to take an active role and acquire information from memory or in the environment (Nisbett & Ross, 1980). During the process, the individual must be aware that not all information may be equally important for the situation at hand. The relevance of the information may differ for various reasons. It can be determined either by a) the subjective importance of the information (e.g., What color do I prefer for my new bike?), b) the probabilistic importance of the information (e.g., How likely is it that it rains?) and c) the credibility of the information source (e.g., Is the person providing the information knowledgeable?). Due to bounded cognitive capacities and time constraints, the individual must decide which information to consider further. Thus, individuals should identify the relevance structure and weight information by its respective relevance. Searching the information based on their weighted relevance has consequences not only for the search process but also for the subsequent judgment or decision. In general, the information that is perceived and further processed highly influences judgments and decisions.

There are different theories and models to describe how judgments are formed (see Plessner, 2010 for more details). In a simplifying framework model, it is assumed that a coherent judgment is formed by integrating and composing available pieces of information once the amount of information is sufficient to do so (Plessner, 2010). Moreover, judgments and the selected information can be influenced by prior beliefs. They can affect how

information is weighted and processed (i.e., top-down process): expectations are generated based on prior beliefs and those expectations in turn influence which information is selected and integrated into the judgment (Plessner, 2010). According to Brunswik's (1952) lens model, judgments in uncertain environments cannot be made solely based on directly perceivable properties. Instead, cues with different ecological validities (i.e., the correlation between the cue and the distal variable) must be used. Consequently, judgments are based on probabilistic information. It is possible that cues are contradictory, resulting in different judgments. Also, individuals may use cues differently, which can be expressed by the correlation between the cue and the individuals' inference. The accuracy of the judgment is then determined by the correlation between the individuals' inferences and the distal variable, indicating how the cues were integrated into a coherent judgment (Brunswik, 1952).

Concerning decision making, the information search does not only reveal specific information on the options but often also the options itself, since the number of decision options in everyday decision contexts is typically not fixed. The individual then needs to select some of the options and subsequently search for relevant information on those options. The relevance of information may differ, as stated previously, and should be considered for the subsequent decision (T. Betsch, 2010).

### **Paradigms for Investigating Information Search**

There are different methods to investigate information search in judgment and decision making contexts (Goldstein & Hogarth, 1997). Many methods trace the process and have been widely used in judgment and decision making research. They trace either the acquisition of information (e.g., information boards or eye tracking, where the decision-relevant information is presented on a monitor and the position and movement of the decision makers' eyes are recorded), the integration and evaluation of information (e.g., think aloud or verbal protocols where participants verbalize their thoughts and internal states during a task), or other processes (e.g., reaction time as a physiological process; Schulte-Mecklenbeck et al., 2017).

In this dissertation, I focus on a specific method for tracing information acquisition, namely information boards. They are one of the standard process-tracing methods and have received much attention in judgment and decision making research to date. With this paradigm, it is possible to investigate different aspects of the search such as amount (i.e., depth), order (i.e., pattern), and start. Since they are the method at the focus of this dissertation, they will be presented in greater detail in the next section.

### ***Information Boards***

Information boards describe decision options on different attributes (cues) in a matrix. The cells contain the consequences (cue values) and are either presented in an open or closed format. In the open version, information can be assessed simultaneously, whereas closed information must be assessed sequentially. In the computerized version of information boards, closed information can be accessed with the computer mouse. Thus, such an information board is also called *MouseLab*. The search process and final decision or judgment are protocolled and can then be analyzed. It is possible to investigate different decision tasks with information boards – one of which includes probabilistic inference decisions. In these probabilistic environments, the information dimensions are assigned a probability, the so-called cue validity – this should be used to weight the relevance of information. This probability can represent the importance of the dimension or the likelihood of a correct prediction provided by the respective cue (Bröder & Schiffer, 2003; Payne et al., 1988). Thus, the expression *probabilistic inference* describes “a special sub-class of judgments in which multiple probabilistic cues are used to determine which of two options is better on a criterion that is not directly accessible” (Glöckner et al., 2010 p. 440).

Information boards have already been successfully adapted for use in research with children (i.e., Treasure Hunt Game, e.g., T. Betsch et al., 2018; T. Betsch et al., 2016), providing a version which is low in complexity for adults even if probabilities need to be considered. This is relevant since adults often have difficulty in dealing with probabilities

(e.g., Reyna & Brainerd, 2007). Thus, the complexity due to probabilistic information in the information boards was discussed as a potential reason for the deviations of adaptive behavior. With this adapted, child version, the cue validities are conveyed in three different ways: they are learned in a separate phase, displayed in a graphical format during the decision phase, and reinforced by feedback after each decision. This is an advantage compared to structural equivalent paradigms used in adult research. Complexity for adults should be sufficiently low to decide adaptively in the specific environments. Usually, in the standard information boards as well as in the adapted version, the cue validities are provided by default (e.g., Glöckner & Betsch, 2008b) or learned in a previous training phase (e.g., Bergert & Nosofsky, 2007). Thus, an active search of source information is not necessary.

### **Source Information**

The relevance of information can depend on its source. Mostly persuasive messages, specifically arguments, come to us from others. As sources, these others are only partially credible (P. J. Collins et al., 2018; Nisbett & Ross, 1980). Individuals should thus always consider the information source as well as whether that source can be trusted – especially when they are laypersons for the topic and the content exceeds their own understanding (Bromme & Goldman, 2014). In such cases, the source should be considered for weighting the credibility of information (Birnbau & Stegner, 1979; Birnbau et al., 1976; Bråten et al., 2017; Stadtler & Bromme, 2014). Hence, “the weight assigned to a piece of advice depends on several factors, including the credibility of the advisor (e.g., Hogarth & Einhorn, 1992), the perceived expertise of the advisor (e.g., Birnbau & Stegner, 1979), and the precision of the advice...” (Zhang et al., 2006, p. 103). Since advice precision often cannot be sufficiently evaluated by laypersons, the indirect evaluation through identifying credible experts is necessary to make informed judgments and decisions (P. J. Collins et al., 2018; Scharrer et al., 2021). The evaluation of source credibility – in the form of either direct

information on the source such as its expertise or probabilistic information such as its cue validity – is thus crucial when searching information for decision making and belief updating.

Characteristics of credible sources is addressed in different research fields. For example, in judgment and decision making (e.g., Birnbaum & Stegner, 1979), social psychology on persuasion (e.g., McGinnies & Ward, 1980, for an overview: Pornpitakpan, 2004), educational psychology on sourcing and multiple document comprehension (e.g., Bråten et al., 2017), cognitive psychology on reasoning (e.g., Wolf et al., 2012), and in philosophy on ethos (cf. Aristotle (trans. 1932), e.g., Koszowy et al., 2022). Due to the scope of this dissertation, the next section will provide an overview of source credibility and, more specifically, source expertise primarily from the perspective of research in judgment and decision making and social psychology.

### ***Source Credibility and Source Expertise***

There are different aspects that indicate source credibility. As already mentioned, they depend somewhat on the research field but similar aspects have been found. Extensive research on credibility evaluations shows that there are two core dimensions: *expertise* and *trustworthiness* are the most relevant aspects identifying credible sources (Hovland & Weiss, 1951; Ohanian, 1990; Pornpitakpan, 2004). Expertise is the extent to which the source is perceived to be able to provide correct information. An expert source can be understood as a source that is experienced and knowledgeable in the relevant domain and therefore is assumed to be competent (Hovland & Weiss, 1951; O'Keefe, 2015). While expertise is a measure of whether the source can know the correct information, trustworthiness describes the willingness of the source to provide this information and the extent to which the recipient regards the information provided as legitimate and true according to the source's own judgment (O'Keefe, 2015; Pornpitakpan, 2004). Commonly, highly credible sources induce more persuasion and attitude change, implying belief change, than low-credibility ones.

Studies showed that people are able to use source information at least sometimes to evaluate the credibility of information (e.g., Birnbaum & Stegner, 1979; Birnbaum et al., 1976; Bråten et al., 2011; Pornpitakpan, 2004; Stenseth & Strømsø, 2019). However, it has also been observed that people do not search for source information spontaneously – because they either do not notice the source information or they do notice it but do not consider it when evaluating information content (Scharrer & Salmerón, 2016). Nevertheless, source and content information combined are enormously important for the overall evaluation. Dual-process models such as the Elaboration Likelihood Model (ELM; Petty & Cacioppo, 1986) and the Heuristic Systematic Model (HSM; Chaiken, 1980) can explain the interplay of source characteristics and message content, which will be described in the next section.

### **Content and Source Information**

According to the ELM, content information and arguments are processed via the central route when the individual is motivated and able to do so (Petty & Cacioppo, 1986). When motivation and ability are rather low, simple context cues such as source characteristics are taken into account for elaboration through the peripheral route (Petty & Cacioppo, 1986). In the HSM, the two processing modes – heuristic and systematic processes – can occur independently but also co-occur in an additive fashion to process argument content and source characteristics (Chaiken, 1980). The heuristic process employs simple rules that have been learned based on past experience and observations such as “experts can be trusted” (Chaiken, 1980; H. Collins, 2018; Maheswaran & Chaiken, 1991), whereas the systematic process focuses on the detailed processing of message content. Individuals should “employ a systematic strategy when reliability concerns outweigh economic concerns and a heuristic strategy when economic concerns predominate” (Chaiken, 1980).

### **Strategies and Biases in Information Search**

Expected utility theory (Neumann & Morgenstern, 1944; Savage, 1954) contributed significantly to decision making research. It states that rational individuals ought to maximize

the expected utility of an outcome. The theory allows to derive normative expectations regarding strategies for information search and subsequent decision making. The principles of the theory were traditionally used to evaluate rationality in decision making (Stanovich, 2009). However, research showed that people systematically deviate from normative expectations in their judgments and decisions (e.g., Kahneman & Tversky, 1979; Payne et al., 1988) and also fail to decide rationally which information to acquire (e.g., logic of confirmation and disconfirmation, Wason, 1968). An explanation for the deviations was the notion that people have limited cognitive capacities and time constraints to process all information necessary to make rational decisions. This is known as “bounded rationality” (Simon, 1955, 1982). With the rise of that approach, the notion of rationality was replaced by adaptivity. Adaptivity means that individuals are able to adapt to the features of the environment. However, it is still discussed whether there is a general mechanism – a holistic process (i.e., single-process models; e.g., Glöckner & Betsch, 2008a; Lee & Cummins, 2004) or discriminant, uniquely identifiable strategies (i.e., multiple-strategy models; e.g., Beach & Mitchell, 1978; Payne et al., 1993) – that allow individuals to adapt their behavior to the environment (Söllner et al., 2014). The approach to adapt by using heuristics and strategies was intensively studied in the “Heuristics and Biases” program by Tversky and Kahneman (e.g., 1974, 1981, 1986) as well as in the “Adaptive Toolbox” approach by Gigerenzer and colleagues (e.g., Gigerenzer, 2008; Gigerenzer & Goldstein, 1996; Gigerenzer & Selten, 2001; Gigerenzer et al., 1999). Heuristics allow one to make relatively good judgments and decisions while using only little information due to limited information processing capacities. If we assume that there are different strategies from which the decision maker must select, several aspects indicate the fit of the strategy to the decision situation, i.e., characteristics of the decision environment and of the decision maker (Lieder & Griffiths, 2017; Payne et al., 1988). Generally, one can differentiate between non-analytic and analytic as well as compensatory and non-compensatory strategies (e.g., Beach & Mitchell, 1978; Payne et al.,



1988). They differ in the amount of information assessed and the cognitive capacities required. Non-analytic strategies are “fairly simple, preformulated rules” (Beach & Mitchell, 1978) that require little time and only little information. Analytic strategies in contrast require one to consider the outcomes of options and the probability with which outcomes will occur after the decision. With compensatory strategies, aspects of an option can be compensated by another aspect of an option. This is not the case for non-compensatory strategies. There, aspects of options cannot compensate each other. It depends on the environment which search strategies are best. One can distinguish between compensatory and non-compensatory environments. They differ in their weight- and, thus, payoff structures: in non-compensatory environments, the dispersion of the weights is large so that high-weight outcomes cannot be compensated for by low-weight outcomes – resulting in relevant versus less relevant information. Hence, searching a subset of information is sufficient in order to make a good decision. In compensatory environments, the dispersion of the weights is low and thus, aspects of outcomes and certain combination of aspects can compensate each other so that all information is similarly relevant – hence, it would be insufficient to search only a subset of information but all information must be considered to achieve high decision accuracy. This distinction requires an adaptivity of information search to the environment. That is, the individual must align their search and decision strategies depending on the situation and the weight-structure of the environment (high vs. low weight dispersion), so that the effort to process the information is reduced but at the same time a high degree of decision accuracy is maintained (Beach & Mitchell, 1978; Payne, 1976; Payne et al., 1988, 1993). Overall, there are a number of studies that have demonstrated that people are capable of selecting their strategies adaptively (e.g., Bröder, 2003; Rieskamp & Hoffrage, 2008).

In the following, I describe a selection of strategies in more detail, namely the ones that play a crucial role in my dissertational work.

An analytic, non-compensatory strategy is the Lexicographic Rule (LEX; Payne et al., 1988, 1993) or take the best heuristic (TTB; Gigerenzer & Goldstein, 1996; Gigerenzer et al., 1999). This is a simple strategy where it is sufficient to focus only on a subset of information – i.e., the most relevant information of the options. This information is attributed the highest relevance weight and thus should be searched first when information is searched sequentially. Other, less relevant – yet potentially available – information can be ignored. One chooses the option that is superior regarding the most relevant information and eliminates the other options. If there are ties between the options (i.e., there is no superior option or more than one is superior regarding the most relevant information), one must consider the second, third, ... most relevant information until the tie is broken. Another analytic, but compensatory strategy is the Weighted Additive Rule (WADD). WADD requires decision makers to consider all of the information provided on each option according to its weight and is thus the most resource-demanding strategy (Payne et al., 1988). A weighted value is calculated by weighting each information according to its relevance and then summing up the values for an overall evaluation of the option. This is done for each option; and the decision is then based on this weighted value – the option with the highest evaluation is chosen. In non-compensatory environments, the predictions derived from these two strategies are extremely similar, leading to the same decision (Payne et al., 1988). Nevertheless, the cognitive effort needed is highly different. However, cognitive capacities are not systematically related to decision accuracy. Depending on the environment, the simple strategies can lead to the same or even better decisions than more complex strategies (Payne et al., 1988). As stated, LEX has advantages regarding the reduction of cognitive capacities and time resources by restricting the consideration of only part of the available information. With increased task complexity (i.e., increase in the number of options and the amount of information), people shift to strategies that involve the elimination of options on the basis of a subset of information (Payne, 1976). If individuals ignore the weight-structure in general, they risk missing relevant information.

Consequently, they make their decisions based on incomplete information. As already stated, there are not only analytical but also non-analytical strategies. They are also quite resource-efficient, since only few analytic qualities are required, such as recognizing the similarity of the current decision with previous decision tasks and the applicability of the rule. However, no extensive evaluation of current information is needed, which is why they are considered to be non-analytical (Beach & Mitchell, 1978). Following the advice of an expert is a non-analytical strategy. Thereby, the credibility of the expert plays an important role (Jungermann & Fischer, 2005).

### **The Role of the Individual**

In principle, there are individual differences in skills and wills that influence how information is searched, judgments are formed, and decisions are made. Judgment and decision making competence must develop over time. In particular, the skills needed to be a good decision maker or form appropriate judgments evolve through childhood and adolescence (T. Betsch et al., 2021; Morsanyi & Handley, 2008). Thus, individuals become better over time (e.g., T. Betsch et al., 2016; Lindow & Lang, 2022), since the required cognitive abilities develop and each single judgment and decision making process is an opportunity to learn (Lieder & Griffiths, 2017). A major skill needed to be able to weight the information according to their relevance is the competence to understand and deal with probabilities, i.e., numeracy, which predicted normatively superior judgment and decision making (e.g., Ashby, 2017; Reyna & Brainerd, 2008). Also, general cognitive abilities were found to influence decision making (e.g., Bröder, 2003). Thus, research showed that both numeracy and intelligence have an impact on judgments and decision making (e.g., Cokely et al., 2018). The will to acquire reliable information is also relevant. This is affected, in part, by the prior beliefs that an individual holds. Since the impact of information search on belief change plays a crucial role in the studies of this dissertation, the topic is now presented in greater detail.

## **Beliefs**

Human information processing is often biased (Nisbett & Ross, 1980; Tversky & Kahneman, 1974) and prone to confirm existing beliefs (Festinger, 1957, 1962; Nisbett & Ross, 1980). The concept of beliefs refers to different types of cognitions such as assumptions and expectations, which are shaped through knowledge and experiences (Kube & Rozenkrantz, 2021). Beliefs can be differentiated from attitudes, because the latter contain an affective component (Ajzen, 2001). However, beliefs are a component of attitudes since an attitude is the sum of beliefs and their evaluation (Theory of Reasoned Action, Fishbein & Ajzen, 1975; Theory of Planned Behavior, Ajzen, 1991). In other words, attitudes are evaluative judgments representing the integration of cognitions (i.e., beliefs) and affects related to an object (Anderson, 1971). In general, beliefs influence how individuals perceive the world, search and judge information, and subsequently make decisions. They influence the perception of different decision options and the evaluation of which is the best option. This is highly relevant in the health context. Imagine, for example, that an individual developed a positive belief towards complementary and alternative medicine (CAM). This belief will likely influence the individuals' perception of the best option, e.g., treatment or remedy, to cure their disease or illness and thus, their subsequent judgment and decision for a treatment or remedy. Thus, judgments and decisions in the health context are likely to be more complex than in other contexts, because personal factors such as beliefs may play a larger role and their consequences may be more significant than for other decisions (cf. Sanders Thompson, 2013). Further, the beliefs can highly conflict with empirical evidence that should normatively guide health decisions. Therefore, it is necessary to assess how beliefs change according to new information – such as empirical evidence or expert arguments.

## ***Belief Change***

In general, people are prone to maintain their beliefs even if it would be rational to weaken or even change the belief due to new information (i.e., belief perseverance, Hovland

et al., 1953; Nisbett & Ross, 1980; Ross et al., 1975). According to cognitive dissonance theory, the effects of new information on prior beliefs usually differ: If the information is consistent with the prior belief, it is more likely to be integrated (Festinger, 1957, 1962; Kube & Rozenkrantz, 2021) and also be perceived as more convincing than conflicting information – even if both types are similarly believable and strong or weak, respectively (Anglin, 2019; Braasch et al., 2014; Petty & Cacioppo, 1986). Thus, the prior belief is maintained and possibly strengthened. If the information contradicts a current belief, this generates cognitive dissonance, which creates a psychological discomfort that the individual strives to avoid or reduce. There are two options to restore consonance: either reject and ignore the information or change the belief (Festinger, 1957; Nisbett & Ross, 1980; Politzer & Carles, 2001). Thus, the individual engages in a variety of strategies to maintain the belief such as addition of consonant information or subtraction of dissonant information; if this does not suffice, the prior belief is changed (Festinger, 1957, 1962). Overall, the theory of cognitive dissonance suggests that the individual does not always change their beliefs in response to new information.

Belief updating models also allow assumptions on how beliefs change in relation to new information. In general, belief updating models are based on different algebraic assumptions but that all allow for deriving the following: New information is evaluated in a weighted-additive fashion with prior belief and thus, the strength of new information for an update of the belief is dependent on the strength of the prior belief. This evaluation process might lead to an updating of the prior belief to the posterior belief (e.g., Anderson, 1981; Hogarth & Einhorn, 1992; Nisbett & Ross, 1980). In general, it is more likely that beliefs will change when the individual has a lower level of commitment to their beliefs, i.e., the strength of the prior belief is relatively low (Wolfe & Williams, 2018). The Belief-Adjustment-Modell (Hogarth & Einhorn, 1992), for example, adapted the general concept of anchoring and adjustment in that the prior belief is used as an anchor and sequentially adjusted on the basis

of new information to form an updated belief. Also, the conditions of the judgment situation such as the task characteristics, response mode, complexity, number of information pieces, and consistence of information influence how new information is processed and included to form an updated belief (Hogarth & Einhorn, 1992).

Previous research often assessed individual belief change with self-report measures (e.g., rating scales). Researchers used the basic design asking participants for their personal agreement with the topic at hand before and after exposure to new information (cf. Nisbett & Ross, 1980). Such a judgment can be considered as “an opinion to what was, is, or will be the state of some decision-relevant aspect of the world” (Yates & Tschirhart, 2006) and allows to investigate belief change after having received new information (Kube & Rozenkrantz, 2021).

### ***Beliefs in Controversial Topics***

Some issues are more likely to result in differing beliefs between individuals. Especially those that are complex but can directly affect people. The complexity often results from a scientific background of the information – as experienced during the COVID-19 pandemic – or from different perspectives within science. For example, the recommendation of wearing face masks during the pandemic was discussed from the perspective of epidemiology, economy, ecology, and sociology, among others (e.g., World Health Organization, 2021). The situation as a whole was unknown and contained great uncertainty that directly affected people’s everyday lives. Scientific results helped to inform policy and socially relevant decisions. However, this information was beyond the knowledge of many people due to their bounded understanding of science (Bromme & Goldman, 2014). In general, scientific and technical developments lead to an increase in the scientific knowledge that is publicly available. Thus, an awareness and understanding of such scientific information is important for individuals to use it to inform their general understanding of the world as well as a basis for decisions (Bromme & Goldman, 2014). Nevertheless, in recent years, many topics highly relying on scientific knowledge along with considerable empirical evidence are

discussed in public. Despite (negative) evidence, consensus among scientists, and the fact that the majority of citizens values scientific research and generally have a positive attitude toward science (Pew Research Center, 2020), the topics remain controversial among citizens (Pew Research Center, 2015). Prominent examples of such topics are vaccinations, climate change, and CAM. The latter is the topic focused on in this dissertation. I will present it in more detail after explaining evidence vs. experience, since this is a highly relevant field of tension in relation to health and (medical) treatments.

Increasing the use of practices that maximize desired outcomes is the core of evidence-based practice across different professions (Rousseau & Gunia, 2016) such as evidence-based medicine (Sackett et al., 1996). In the context of science, there are slightly different perspectives on evidence depending on the methodological approach. For the understanding of this dissertation, I emphasize on evidence as an argument based on empirical validity – a perspective within the empirical sciences, i.e., natural sciences. This is usually also the approach to evidence in medical and medical-related contexts. Evidence-based practices in this context are practices whose effectiveness is based on scientific knowledge, mainly derived from randomized studies with control groups or further supported by meta-analyses. If thinking and beliefs are not based on scientific evidence, decisions and behavior are also not guided rationally (Stanovich & West, 1997). Even though decisions affecting the individual as well as the society benefit from considering evidence (Barrett, 2012; Bromme & Goldman, 2014; Koehler & Pennycook, 2019), some people have the tendency to weigh their own experiences and anecdotal evidence equally to scientific evidence and, thus, trust personal beliefs and pseudoscience more (e.g., Lewandowsky et al., 2012; Schmaltz & Lilienfeld, 2014). This can have severe consequences, since anecdotal evidence or personal experience are not comparable to scientific empirical evidence. Anecdotal evidence often relies on single events where there is no control group and no control of confounding variables. Thus, the observed effects may only be a result of coincidence. When beliefs are

based on anecdotal evidence, this can lead to holding a vast number of irrational beliefs that result in low vaccination rates, paranormal and magical convictions, or the rise of CAM (Barberia et al., 2018; Cook & Lewandowsky, 2016; Hornsey & Fielding, 2017; Matute et al., 2015). These misbeliefs can form a basis for approaching pseudoscientific practices. They intentionally seem scientific on the surface but do not withstand any scientific standards, e.g., homeopathy as a popular form of CAM (Barberia et al., 2018). Homeopathy is based on the principle of 'like cures like'. Usually, homeopathic remedies are administered in highly diluted concentrations (IQWiG, 2021) – they are so highly diluted that they actually do not contain any active ingredient or chemically significant amount of the substance. Thus, there is no plausible scientific basis for the claimed principles; rather, they conflict with scientific laws. Extensive research has shown that there is no evidence for effects of homeopathic remedies beyond placebo effects (e.g., Mathie et al., 2019; Mathie et al., 2014; Mathie et al., 2017; Mathie et al., 2018; National Health and Medical Research Council, 2015; Shang et al., 2005), so it is largely resolved from a scientific point of view. Nevertheless, 34 % of Europeans considered homeopathy to be scientific (European Commission, 2005). Assuming that homeopathy is reliable can result in serious health and economic problems. Despite all this, homeopathy is popular and enjoys widespread use. For example, it is the most favored form of CAM in Germany – 55 % report having experience with homeopathic remedies and only 26 % claim to refuse them (Hillienhof, 2020). German pharmacies alone turned over approximately 633 million Euros with homeopathic remedies for self-medication in 2020 (Bundesverband der Arzneimittel-Hersteller e.V., 2021). Homeopathic treatments and remedies are partly covered by public health insurers in Germany (Jansen, 2017; Relton et al., 2017) – resulting in an annual cost of millions (the exact indications vary between 9 and 20 million for the year 2019) to public health insurance without the cost for physicians and pharmacists as well as follow-up costs due to delayed treatment with effective remedies (Feldwisch-Drentrup, 2019; ZDF, 2022). This is a problem in the healthcare system –



covering costs for treatments that lack scientific evidence – and results in controversial and at times heated debates in both politics and the public. The issue is of great relevance in Germany at the moment, as the current Minister of Health is scrutinizing the possibility of removing homeopathy from the list of optional statutory benefits (ZDF, 2022).

### **Research Approach**

When investigating judgment and decision making, researchers often use paradigms that are quite abstract and do not necessarily resemble the real world. Not only a more realistic context but also an active search of source information is missing, so that decision making processes are not always transferable to everyday problems. In real-world contexts, it is not only of interest when individuals rely on others as sources, but also whether they do so rationally. The standard information boards usually provide source information by default and participants did not need to search for that. However, this is different in the real-world. Not only may it be difficult to find information on the source (e.g., online), but actively searching that information definitely requires time and effort to do so. Thus, it is important to examine whether individuals search for and consider information on the source simultaneously to their content information search. This was not possible with the current paradigms of judgment and decision making research. Consequently, in my dissertation, I took the information boards often used in decision making research and modified them stepwise to include an active search of source information. Thus, in the modified information boards, information on the source needs to be actively searched. The otherwise stated probabilistic cue validities are further replaced by text information on the sources, e.g., their expertise. Since expertise is not symmetrically distributed, laypersons must rely on experts (Bromme & Goldman, 2014; Jungermann & Fischer, 2005) in real-world contexts. For this context, the modified information boards do not contain (binary) probabilistic information for decision making but provide content information in the form of arguments to assess influences on beliefs. Further, the modified information boards do not require a decision between different options but rather

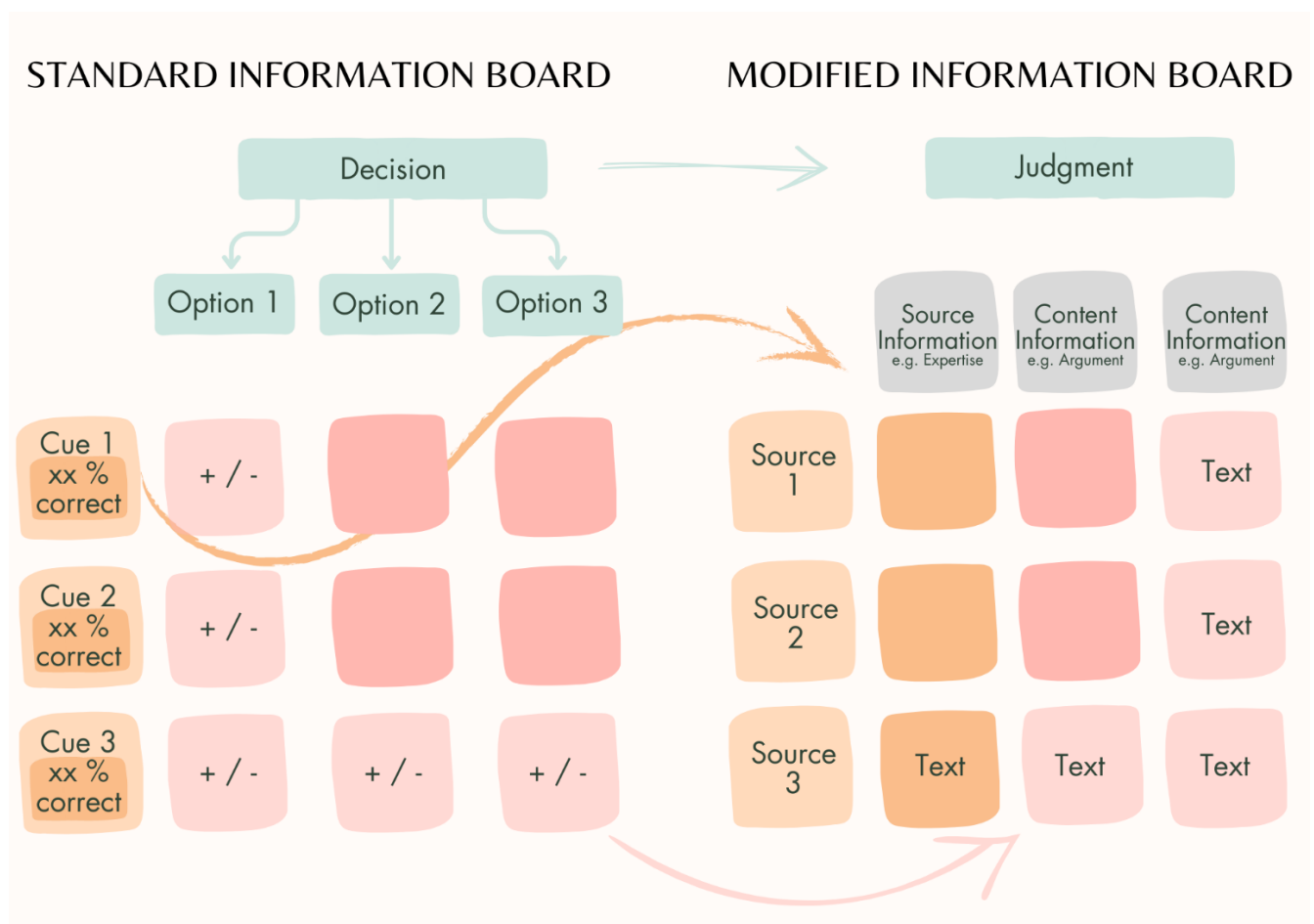
a judgment on the agreement with the topic, reflecting belief (change). Thus, it is possible to investigate whether individuals consider arguments provided by others for their own beliefs. In addition, I changed the setting to a relevant application field, specifically homeopathy. I took up the discussion on whether health insurers should cover the costs for homeopathic treatments and remedies as well as the debate on the effectiveness of homeopathic remedies beyond placebo effects and used these issues for the modified information boards. Hence, in summary, the modified boards contain three relevant changes:

1. Source information: Initially, these were cue validities, i.e., probabilistic information provided by default in the paradigm. In the modified version, information on the source, e.g., its expertise, is embedded. Additionally, the information is not given by default but instead must be actively searched.
2. Content information: Usually, the information boards do not provide extended information. In most cases, binary information on gains and no gains or losses are presented for each option. Otherwise, short information such as prices are given. In the modified boards, participants are confronted with arguments – i.e., texts with approximately 30 words.
3. Outcome of information search: Initially, participants have to decide on one of the options given. However, when confronting people with topics of the real world, they naturally have an existing prior belief in relation to the topic. As a consequence, the modified information boards were not used in combination with decisions. Instead, participants had to judge their agreement with the topic before information search (prior belief) and after information search (posterior belief). With this it was possible to additionally investigate whether the participants' beliefs changed as a result of being confronted with new information.

Figure 1 displays both versions of the information boards in comparison to provide an overview of the mentioned changes and how these result in the novel paradigm.

**Figure 1**

*Comparison of a Standard Information Board and the Modified Information Board*



*Note.* In closed information boards as presented here, the cells of the matrix need to be searched. Thus, light red colored cells resemble already searched information whereas darker red colored cell resemble information that can still be assessed.

With these changes, the information search of source and content information can now be examined in parallel. Thus, I present a new attempt to empirically distinguish between source and content information search and compare both processes within the same paradigm. Consequently, the innovative paradigm aids to investigate the questions arising during the information search process, namely: “Who am I listening to?” and “Whose information do I value?”. As already mentioned, the answers to these questions are highly relevant for subsequent beliefs, judgments, and decisions. Thus, they represent key questions, since sources in the real-world are – depending on the topic – often not fully reliable. Hence, we

need to know how people approach these questions and, since they do this differently, we should investigate why they are doing it differently. Does training in scientific methods make a difference? Does specific knowledge help people to base their judgments and decisions on the most relevant information? Are there personality traits and cognitive factors that predict why people have beliefs that are contrary to the state of the science – and which of them are, in principle, changeable? To examine this closer, I conducted the studies presented in this dissertation. In these studies, I gradually moved away from the standard information board setup. In Article 1, the standard information boards were used to examine decisions. The deviations of participants' behavior led to the next study. Thus, in Article 2, I moved away by (a) changing the cue validities to one piece of source information per source, but still stating it by default, (b) providing content information in form of text arguments instead of binary predictions, and (c) moving away from decisions to judgments regarding a controversial topic to investigate belief change. In Article 3, I moved further away by (a) changing the cue validities to two pieces of source information per source and adding an active search of source information, (b) providing content information in form of text arguments instead of binary predictions, and (c) moving away from decisions to judgments regarding various controversial topics to investigate belief change extending the range of topics. This version demonstrates the final modified information boards. In Article 4, I used the modified information boards in an online setting with (a) one piece of source information per source and an active search of source information, (b) content information in the form of text arguments, and (c) judgments regarding a controversial topic to investigate belief change. In the following, I will describe each study in more detail.

Article 1 investigated the information search of participants who were expected to have high cognitive abilities – namely, university PhD students, postdocs, and lecturers. Additionally, we ensured high motivation through a generous performance-related payment, since ability and motivation significantly influence the quality of decisions. The study was

conducted with the standard information boards of judgment and decision making research for which previous studies found interindividual differences. Within the highly qualified group of participants in this study, we aimed to examine possible effects due to differences in training in scientific methods. We used information boards with probabilistic source information, the cue validities, which were given by default. The cues' predictions were either high or low in conflict depending on the pattern of the matrix. The highly qualified group of participants was expected to be aware of the importance of source evaluation due to their extensive academic education. However, results showed deviations of accurate decision behavior when the decision situation showed higher conflict and the evaluation of source information was more demanding. This led to the studies presented in the other articles.

Article 2 presents a study that used a design resembling real-world contexts more closely. Participants needed to search information in relation to a controversial topic, namely homeopathy. Source information was not presented with probabilistic information but with information on sources' expertise, specifically their training or role (i.e., physician and patient). This was again given by default. Further, four pieces of information (i.e., arguments) were provided but information search was limited to a single piece of information (i.e., one argument). The arguments used are real statements that were found online and carefully selected out of 24 arguments after pre-testing these. In this study, we wanted to investigate the information search with an emphasis on the consideration of sources as well as the influence of the searched information on prior beliefs. Within the limited information search, participants were able to prioritize information provided by experts over information by laypersons. However, there were deviations due to participants' behavior intentions. Those also affected belief change more than argument exposure. Nevertheless, a single information might not have been enough to change a prior belief. In the real-world, people are also confronted with more information. Additionally, they need to search for source information in most cases. The study in Article 3 follows from this.

In Article 3, we sought to modify the standard information boards by integrating an active search of source information to resemble many real-world contexts where source information must typically be searched. In addition to the integrated active information search, the type of information was changed compared to the standard paradigm to also be closer to real-world situations. As in Article 2, source information was provided with information on sources' expertise, specifically their training or role (i.e., physician and patient) as well as information on potential conflicts of interest. We investigated the usefulness of these modified information boards in a study where participants were presented with information boards for different topics out of two domains (i.e., health and education). We also assessed belief change after information search. Results showed that participants considered source information in their search, which indicates that the structural extension of the standard paradigm was successful. Thus, the modified information boards can be used to investigate source and content information search simultaneously. This was also realized in the next study, presented in Article 4.

Article 4 describes a follow-up study with the modified information boards in a computerized version. In this study, I focused on only one of the topics out of the health domain, specifically homeopathy. For that, I have taken up the discussions on the coverage of homeopathic remedies by health insurers and homeopathy's effectiveness. Further, this time, source information was only varied regarding source expertise to enable a clearer distinction of the sources and evoke a strategy where participants focus on experts and prioritize their arguments. Thus, it was expected that participants limit their search without having a restricted search amount limiting their search per default. In addition to information search, its influence on prior beliefs was assessed, again. Results showed that participants prioritized source information for the start of their search. However, they deviated from expected behavior regarding the search amount – it seemed that they did not use a strategy that limited their search by prioritizing specific information (e.g., expert or belief confirming). Instead,

they searched almost all information available. Beliefs changed for around a quarter to a third of participants.

Article 5 assessed which cognitive and personality factors can explain differences in the belief in CAM in general and belief in homeopathy specifically. On the one hand, beliefs highly influence many factors, such as the intention to perform a certain behavior. This behavior can be the search of information or the intake of a remedy. On the other hand, beliefs, themselves, are influenced by specific individual and social factors. How these factors shape beliefs and subsequently behavior intentions can make a crucial difference, especially in the health contexts. For example, CAM as well as homeopathy are topics that are largely clearly understood from a scientific perspective. Nevertheless, they remain controversial in the public and political spheres and continue to have many adherents. Thus, it is important to obtain insights into the determinants and cognitive processes of individuals who believe in complementary and alternative medicine as well as homeopathy. In previous studies, various predictors have been explored. However, most researchers examined only a subset of predictors and investigated them within small models. In doing so, their relative predictive power remains unknown. We aimed to close this gap in the literature by investigating the robustness of 21 variables derived from previous studies and pretests. Results showed that 20 % of variance in belief in CAM can be explained by five predictors. 21 % of variance in belief in homeopathy can be explained by eight predictors. Thus, some predictors could explain both forms of beliefs, whereas others explain either one or the other. Individuals believing in CAM and individuals believing in homeopathy differ but also share certain cognitive biases and individual factors that make them perceive the word differently.

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# Article 1

When even the smartest fail to prioritise:

Overuse of information can decrease decision accuracy

The article was published in an international, peer-reviewed, academic journal:

Aßmann, L., Betsch, T., Lang, A., & Lindow, S. (2022). When even the smartest fail to prioritise: overuse of information can decrease decision accuracy. *Journal of Cognitive Psychology*, 34(5), 675–690. <https://doi.org/10.1080/20445911.2022.2055560>

## Article 2

Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations

The full article can be found in the appendix on pages 71–98.

The article was submitted to an international, peer-reviewed, academic journal.

Aßmann, L. & Betsch, T. (2023). *Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations*. Manuscript submitted for publication.



## Article 3

How do people search information on content and  
sources?

Integrating source search in information boards

The article was published on a preprint repository:

Aßmann, L., Futterleib, H., Betsch, T., Thomm, E., & Bauer, J. (2021). *How do people search information on content and sources? Integrating source search in information boards.*

<https://doi.org/10.31234/osf.io/jydnv>

## Article 4

You ask the experts – but then you don't listen to them:

Prioritization of source expertise for search start but not  
for search amount

The full article can be found in the appendix on pages 99–124.

The article was submitted to an international, peer-reviewed, academic journal.

Aßmann, L. (2023). *You ask the experts – but then you don't listen to them: Prioritization of source expertise for search start but not for search amount*. Manuscript submitted for publication.

## Article 5

# Medical decision making beyond evidence: Correlates of belief in complementary and alternative medicine (CAM) and homeopathy

The article was published in an international, peer-reviewed, academic journal:

Aßmann, L. & Betsch, T. (2023). Medical decision making beyond evidence: Correlates of belief in complementary and alternative medicine (CAM) and homeopathy. *PLOS ONE*, 18(4), e0284383. <https://doi.org/10.1371/journal.pone.0284383>

# **General Discussion**

In the following section, I will discuss the overall results of the studies presented in this dissertation. The five articles examined information search in different environments to modify the standard information boards in order to investigate information search in contexts that more closely resemble real-world conditions. In addition, individual differences – specifically, cognitive and personality factors as well as behavior intentions – were scrutinized to investigate which skills and wills affect information search and predict questionable beliefs.

### **Summary of Results**

Article 1 examined the information search and decision making of highly able (PhD students, postdocs, and lecturers) and motivated (i.e., generous payment for correct decisions) participants with the standard information boards. Participants were not consistently able to prioritize the most relevant information and, thus, deviated from accurate decision making in conflicting situations. Their overuse of information (i.e., also considering less relevant information) without appropriately weighting its relevance potentially led to those deviations. Individual differences in statistical-methodological competence could not account for them.

Article 2 presents a study with a limited information search. Participants had to search a single piece of information out of four pieces of information provided. Within this limited search, they were able to focus on expert arguments. However, in this study, participants' behavior intentions led to deviations from prioritizing arguments from expert sources over arguments from non-expert sources. The influence of direction of the individual pieces of information on the prior belief was tested but showed no effect. However, behavior intentions appeared to influence belief change.

Article 3 describes the changes of the standard information boards in detail and presents a study in which the usefulness of the modified information boards implemented with cards was tested. The integration of an active source information search allows for the simultaneous search of source and content information in contexts that more closely resemble

real-world conditions. The changes appear to be appropriate since participants searched both content and source information. They focused on source information, i.e., expertise, at the beginning of the search and continued on to content information. In general, participants searched more content information than source information. Beliefs changed for some of the topics after information search.

Article 4 investigated the information search with the modified information boards in an online, computerized version. Results show that participants prioritized information for the search start by mainly beginning with source expertise. However, they did not prioritize for search amount by focusing on expert arguments or arguments confirming their prior beliefs. Instead, they searched almost all information available. After searching information, approximately one quarter of participants changed their beliefs.

Article 5 focused on cognitive and personality variables. We examined the robustness of 21 predictors of beliefs in CAM as well as beliefs in homeopathy to obtain insights into key determinants of those beliefs. Individuals believing in CAM and homeopathy have certain personality characteristics and cognitive biases which might lead to a different perception of the world as well as the understanding and utilization of information, resulting in questionable beliefs. However, it appears to be inattention to accuracy rather than ability that explains such beliefs.

Over all studies, participants appeared to be aware of the importance of information providers – i.e., the information sources. When cue validities were already given, participants were able to identify the most relevant cue – mainly in explicit decision contexts. When sources' expertise had to be actively searched, participants focused on that information for the beginning of the search process. Knowing where the information comes from is an important aspect of information search (e.g., Anderson, 1971; Birnbaum & Stegner, 1979; P. J. Collins et al., 2018); and participants appeared to be aware of this notion. However, actually using the most relevant information appeared to be much more difficult. In standard information

boards, participants overused information and might get confused when predictions contradicted. As a result, they deviated from accurate behavior and decided more often for the options with inferior outcomes. This conflict of information is also relevant in most real-world contexts, including homeopathy. Scientific results conflict with anecdotal evidence provided by patients and even physicians. Whereas empirical evidence has shown that the treatments and remedies have no effect beyond the placebo effect (e.g., Mathie et al., 2018; National Health and Medical Research Council, 2015; Shang et al., 2005), numerous testimonials are available from users who confirm its effectiveness above and beyond the placebo effect based on their personal experiences (Lüdecke, 2014).

Altogether, the studies provide new insights. The findings suggest that individuals understand that the relevance of information may vary and that they are able to effectively consider source information for search start. Still, they are not necessarily able to effectively consider source-weights in their further information search – especially in conflicting situations.

### **Information Search & Consequences**

Consistent with the results from decades of judgment and decision making research (e.g., Bergert & Nosofsky, 2007; Gigerenzer et al., 1999; Lee et al., 2017; Payne et al., 1988; Rieskamp & Hoffrage, 2008; Rieskamp & Otto, 2006), individuals were able to weight information according to its relevance in explicit situations with the standard information boards. Replacing the probabilistic information with explicit information on the sources' expertise – an information that individuals are familiar with from their everyday lives – fostered the prioritization of expert information within a single information search. When information search was not limited, explicit source information did not appear to aid information search, as participants did not prioritize information from expert sources and, instead, overused information. In addition, the environment and individual differences influenced information search and subsequent decisions and beliefs. When the information

was conflicting in the standard information boards, participants had difficulty prioritizing the sources with the highest probability of providing the most relevant information. Despite learning cue validities during a training phase, which were then displayed in the subsequent decision phase, participants were not able to use source information appropriately and, instead, deviated from adaptive behavior. This was independent of participants' individual differences regarding their training in empirical methods and statistics. I expected participants who gained deeper insights into control group designs and probabilities during their career to better differentiate between the relevance of the information provided. However, results showed that this was not the case. Still, individual differences in behavior intentions led to deviations in a more realistic context within the modified information boards. Participants with the intention to take homeopathy in the future more often searched information from other non-medical experts, i.e., the patients. Throughout the studies, participants demonstrated an overuse of information. This appeared independent of the paradigm used when information search was not limited. Hence, participants did not prioritize information according to its relevance – regarding neither their personal relevance (i.e., belief confirming) nor their normative relevance (i.e., weight structure and expertise).

There are several possible explanations for these patterns found across the studies. First, participants' ability to consider the sources of information even when they had to be actively searched is in line with heuristics (e.g., "Experts can be trusted.") as well as expectations from normative and descriptive models from decision making research (Chaiken, 1980; H. Collins, 2018; Gigerenzer et al., 1999; Maheswaran & Chaiken, 1991; Neumann & Morgenstern, 1944; Payne et al., 1988). According to those models, individuals must weight information depending on its relevance. The relevance is typically determined by the cue validities – i.e., the source information in the modified information boards. Second, the deviations might occur because participants set an individual evidence threshold that needed to be exceeded by the information searched (evidence accumulation models, cf. Lee &



Cummins, 2004). Thus, participants did not focus only on the most relevant information but, instead, extended their search and also considered less relevant information. This can be accounted for in both probabilistic environments and the more realistic environment in which source information is described through expertise (and benevolence). Third, the salience of source information might have affected the effective consideration of source information for search start, which was then not sufficient for further consideration. Due to the previous learning phase in Article 1 and the active search of source information in Article 3 and 4, participants paid attention to this information and were able to use it when the situation was not demanding. However, the importance of continuing to use this information when evaluation was more complex was likely not transferred.

When people search information in the real world, they are typically confronted with a wealth of information from different sources. This often results not only in overload (Bawden & Robinson, 2020; Schmitt et al., 2018) and inconsistencies due to limited cognitive capacities (Miller, 1956; Simon, 1979) but also in biases – e.g., related to judgments and decision making (Kahneman, 2011). Thus, people must prioritize information. In the present studies, participants investigated nearly the entire information board. This might be a result of the environment. It is possible that the information boards were not as demanding as the real-world. In most of my studies, participants were confronted with more than one piece of information. However, this information was highly pre-structured and less abundant and complex than in most real-world information search settings. Additionally, participants might have been motivated to obtain all available information out of curiosity, which was possible – contrary to the real-world – because all pieces of information were easily accessible due to the pre-structured environment. Nevertheless, such an overuse of information can have different consequences, both in the experimental setting as well as in the real-world. No matter which model serves as a theoretical background, all have in common that the information that are searched are crucial for subsequent judgment, decisions, and beliefs. According to

Plesser (2010), the available pieces of information are integrated into a coherent judgment – thus, the accuracy of the judgment depends on the information basis. The same accounts for Brunswick's Lens model (1952). The information accessible (i.e., proximal cues) are used to infer a distal variable in order to achieve an accurate judgment. Also, decision making models (e.g., Beach & Mitchell, 1978) include the importance of appropriately weighting information relevance. Concerning belief updating models, the belief is adjusted with regard to new information (e.g., Hogarth & Einhorn, 1992). Therefore, the following applies for all models: if the incoming information is questionable, it has cascading effects on subsequent levels, resulting in, for example, suboptimal decision-making, distorted judgments, and a persistence of unfavorable beliefs that will not be changed.

We can also see the consequences of the overused information on an empirical level within the studies. The results show that ignoring the varying relevance of information had implications for subsequent decisions and beliefs. In Article 1, for example, participants deviated from accurate behavior, which led to a decrease in decision outcome quality. In Article 3 and 4, participants searched information in order to make an informed judgment and possibly change their beliefs. They could search as much information as they liked and as often as they wished. Due to the unlimited search for information, information could directly conflict with each other when a large amount of information was searched. Since most participants searched all information provided, they were confronted with contradicting information before providing a second judgment concerning the topic. Thus, it is possible that arguments compensated each other when integrated into the underlying belief structure according to belief updating models (cf. Anderson, 1981; Hogarth & Einhorn, 1992). When new information, e.g., the pro argument from Expert A, was evaluated in a weighted-additive fashion with the prior belief, resulting in an updated belief, that updated belief might have changed back in the other direction after the contra argument from Expert B was evaluated as a subsequent piece of information. Belief change was only retrieved after information search

and not after each piece of information. Thus, slight changes during the process were not traced. However, the overall result of information searched is of greater interest, which indicated that there was minimal substantive change in beliefs. The extensive and unprioritized information search resulted in belief change for some participants but belief perseverance for the majority of participants. Presumably, the presentation of short arguments each provided by a single source were not sufficient to change beliefs to a greater extent. The information might not be enough to influence beliefs that were built on much more information and likely maintained for years. However, especially with regard to this, it is noteworthy that beliefs changed in a quarter of the participants. The stability of these changes remains unknown. However, based on the pre-post design, it seems that even a relatively small amount of information can be capable of inducing belief change.

### **Paradigm**

One major contribution of this dissertation to judgment and decision making research are the modified information boards. They represent a new paradigm for the study of simultaneous search of source and content information. The modifications of the standard information boards were appropriate to investigate information search in contexts that more closely resemble real-world conditions. Nevertheless, the structure of the modified information boards remains highly flexible, allowing for various variations within the boards.

For example, the information provided on the source can be increased and decreased. We varied the type of source information presented. Operationalizing weights of sources without relying on probabilistic information can be seen as a methodological challenge in non-probabilistic studies. In the pilot study, participants were provided with information on the sources' expertise and their potential conflict of interests (i.e., their benevolence and integrity, cf. Hendriks et al., 2015). Since sources with the same expertise level still might differ on other factors, participants could evaluate more information on the source. However, this also adds to complexity. Thus, in the second study, participants could only search for

information on source expertise, which allowed to rank the sources' according to their expertise more clearly – thus, making it easier for participants to prioritize the information depending on its relevance. Another option is to change the differences in expertise. It would be interesting to more strongly vary the dispersion of expertise with different patterns.

Previous research on judgment and decision making showed that participants recognized varying dispersions of source qualities – i.e., cue validities, which can be formal variations of source expertise provided as probabilities – and consequently adapted their information search and choice behavior depending on the dispersion (e.g., Betsch et al., 2016; Bröder, 2000). In the studies using the modified information boards presented in this dissertation, the sources were also differently dispersed regarding their level of expertise. Thus, replacing probabilistic information with information on expertise having a different dispersion appears to be suitable for the research aim and still makes it possible to distinguish between more relevant and less relevant information through a differentiation of source relevance. In Article 4, for example, dispersion of expertise varied between the topics. Expertise was relatively less dispersed within the health insurance topic, with representatives from respectable institutions as experts and journalists as laypersons, whereas expertise was relatively more dispersed within the effectiveness topic, with physicians as experts and patients as laypersons. Results showed that participants started even more often with information on source expertise when the dispersion was greater (i.e., within the effectiveness topic). The effect of dispersion is thus in line with decision making research (e.g., Betsch et al., 2016). High dispersion emphasizes the varying relevance of the sources. In relation to decisions, an environment with high dispersion of probabilities provides the opportunity to focus only on the most relevant information; and, if that information discriminates between the options, the favored option is usually an accurate decision (Gigerenzer & Gaissmaier, 2011). This can be transferred to the more realistic environments of the modified information boards. In real-world contexts, it can also be expected that an adjustment of the information search to match the structure of source

credibility distribution is successful for obtaining relevant information. Even if differences between the sources and the distribution of their expertise, for example, depends more on subjective weights compared to the objective weights in a probability distribution, it still can serve as a reliable indicator. Hence, the different degree of dispersion appeared to be perceived by the participants. Consequently, the differences between the sources and their relevance became more apparent and could be perceived as significant by the individual, resulting in a prioritization of experts for search start.

Further, the content information can be adjusted. We provided participants with real arguments stated by different individuals online. They consisted of approximately 30 words each. However, other formats such as pictures or audio files as well as longer formats such as blogs, newspapers, and research articles or info graphics can be incorporated into the information boards to investigate how information of different modes and lengths is searched as well as whether that information impacts subsequent judgments and decisions.

It is also possible to limit information search with different methods. The paradigm can be combined with time pressure so that participants have only a limited time to search for information before they have to provide their judgment or make a decision (cf. studies with the standard information boards combined with time pressure: Bröder, 2000; Bröder & Schiffer, 2003; Payne et al., 1988, 1993). Participants could also be required to pay for each piece of information searched. In studies using the standard information boards, information costs forced a prioritization during information search (e.g., Bröder, 2000; Newell & Shanks, 2003; Payne et al., 1988, 1993). Those features resemble the constraints in the real world while maintaining the advantages of the paradigm. The computerized version already contains the necessary technical features to implement these constraints.

The modified information boards can be used not only in combination with judgments but also to investigate decision making. Here, I presented studies in which the process from prior belief to information search to posterior beliefs was traced to obtain insights into

influences of information on belief change. However, it would also be possible to assess the influence of an active source and content information search in relation to subsequent decisions. Applied decision making is highly relevant in the health context. For example, individuals must decide between different treatment options. The recommendation of the best option might vary depending on the physician (i.e., expert). This can be displayed with the modified information boards including an active search of source information.

In the studies conducted for this dissertation, we investigated information search of adults. However, the modified information boards can also be used in research with children and adolescents. Hence, it is possible to investigate the formation of critical, evidence-based thinking from school age onwards. For example, it can be examined whether different information formats of the environments influence the development of probabilistic thinking and the consideration of source information for the evaluation of information.

### **Relevance of Information Search in Real-World Contexts**

Many of the problems we are faced with as individuals and as a society arise from questionable beliefs as well as biased reasoning, judgments, and decision-making. This applies for numerous issues from global warming (Biddlestone et al., 2022; Hornsey, 2021) to health topics, e.g., use of questionable treatments and/or rejection of recommended treatments (Attwell et al., 2018; Browne et al., 2015). Thus, understanding why people show these biases and how they are rooted in a biased information search resulting in an insufficient information basis is an important step in countering the errors and more effectively addressing these problems (Hornsey & Fielding, 2017). If available, the information we should base our judgments and decisions on is evidence (Stanovich & West, 1997). The best available evidence should guide the conclusions we derive and decisions that are made – even on a societal level – and be used as a guideline to reduce disagreement (Barrett, 2012; Bromme & Goldman, 2014; Koehler & Pennycook, 2019). Science provides and adjudicates such evidence in the best possible way despite its own imperfections – it is still the best option we

have to gain evidence (Koehler & Pennycook, 2019). If individuals hold onto their beliefs and biased reasoning despite lacking or contradicting evidence, it might result in misinformation and irrationalities (e.g., Lewandowsky et al., 2012; Schmaltz & Lilienfeld, 2014). These can also create tensions between individuals and result in delayed decisions or inaction during crises (Bauer & Kollar, 2023). However, individuals in a knowledge society must actively engage in public life and participate responsibly. Participating and behaving responsibly cannot be based solely on subjective beliefs – it must be critically reflected on the best available knowledge. Thus, a central challenge for society is therefore to foster the abilities to use scientific knowledge in an informed and critical manner. The availability of a vast amount of information – independent of type and source – emphasizes the importance of such skills. Especially online, one has almost unlimited access to information, which in most cases is without gatekeepers ensuring its quality (Flanagin & Metzger, 2007; Scharrer & Salmerón, 2016). Thus, we need to know how people search for information and whether they are able to consider and evaluate the sources of information. This forms the basis for an individual being able to recognize reliable information and credible sources. Gaining insights into the search process can reveal how people prioritize source and content information. Based on these insights into information search, source consideration, and source evaluation, it is possible to design interventions for improving the skills, preventing and encountering irrational beliefs, and promoting the competent use of scientific evidence.

Within the studies of this dissertation, it seems that participants were certainly capable of searching for information about the sources and prioritizing them for the start of their search. Thus, it is not a matter of teaching people that information about sources is important. Rather, it seems to be difficult for people to use this information appropriately afterwards for subsequent search, judgment, and decision making. Thus, people may possess the necessary skills to find credible information but lack the skills to benefit from knowing this information. This result provides a concrete indication for an intervention. However, another possibility is

that they lack not the skills but the will to use this information. There are two explanations for this unwillingness. First, a growing body of literature shows that individuals sometimes deliberately decide against searching or using certain information even if it would be rational to do so (i.e., deliberate ignorance, Gigerenzer & Garcia-Retamero, 2017; Hertwig & Engel, 2016; information avoidance, Golman et al., 2017). Deliberately ignoring or avoiding information serves different functions such as emotion regulation and belief maintenance. A form of this avoidance behavior is to physically obtain the information but to not pay attention to the information obtained (Golman et al., 2017). This leads to the second explanation: Participants might not have been sufficiently motivated to process information. Thus, it would be inattention rather than inability to use the information. Especially since scientific related information is more complex than much other information that individuals are confronted with daily, it is more cognitively demanding to deal with. The perceived relevance of the topic for oneself can be a factor influencing the motivation and attention that the individual is willing to invest in dealing with this information. Various studies in the context of judging information accuracy found that accuracy is highly related to motivational factors and that a lack of reasoning explains, for example, susceptibility to fake news better than motivated reasoning (e.g., Pennycook & Rand, 2019; Rathje et al., 2023).

As already mentioned, it can be a strategy to not deal with certain information in order to maintain one's beliefs, since holding certain beliefs is highly connected with the self. Thus, individuals strive to preserve them. Nevertheless, there are also factors influencing beliefs that, in principle, can be changed. It is crucial to determine the magnitude of the influence of skill and will compared to more stable factors (e.g., gender, personality) in order to identify promising starting points for further research and interventions. The study in this dissertation clearly showed that there are likely changeable factors influencing beliefs – some of the predictors offer promising starting points for interventions. Especially cognitive factors related to certain knowledge (i.e., ontological confusions or spiritual epistemology) or



perceptions (i.e., illusory pattern perception) provide potential to be changed by providing correct knowledge or knowledge on central mechanisms. For example, Barberia and colleagues (2013; 2018) presented educational interventions to reduce causal illusions – which is highly relevant in the context of CAM and pseudoscience and related to illusory pattern perception – by introducing participants to the concept of experimental control, the need of base rates to determine causality, and imparting knowledge on specific effects such as confirmation bias. The concept of these short educational interventions can be transferred to the relevant factors found to explain differences in belief in CAM and homeopathy. When individuals are presented with corrected information that specifically emphasizes core knowledge (i.e., for reducing ontological confusions) and meta-knowledge (i.e., humans tend to look for patterns, which is often useful but can lead to biased perceptions; Hand, 2014), it is plausible that not only their abilities but also their motivation to acquire accurate information as a basis for subsequent beliefs, judgments, and decisions may be enhanced.

### **Limitations and Future Research**

The empirical data presented were collected online or in the laboratory with randomized control trials. This ensured the internal validity of the results. Even if the search environment and the scenarios of Article 2 to 4 more closely resembled real-world conditions, they do not provide evidence about information search in real-world environments. Thus, concerns about the external validity of the findings can be raised, especially since the environments for information search were highly pre-structured. However, this structure is necessary to gain insights into the information search process. Nevertheless, further studies should vary the systematic structure of the information boards.

It can be considered whether it is necessary that source and content information are equally distributed in the information boards (e.g., Article 3: two kinds of information on the source and two kinds of information on the content). An unequal distribution (e.g., Article 4: one kind of information on the source and two kinds of information on the content) might

have an impact on results and analysis possibilities. This is especially the case when participants do not prioritize information and do not use a strategy to search information. However, the unequal distribution resembles the real-world more closely, where typically more content than source information can be searched. Results showed that participants were sensitive for expertise. Thus, the implicit indication through the affiliation/role was successful. However, this only demonstrates one aspect of the sources' characteristics: whether the source can be expected to have proper knowledge of the topic. In most real-world situations, it might not be enough to evaluate the sources' expertise through their affiliation in isolation to their provided information. Sources with the same expertise level still might differ on other factors. For example, experts can be employees of lobbying organizations, which leads to potential conflicts of interests (König & Jucks, 2019). This is often the case in the field of homeopathy. Physicians, practitioners, and pharmacists might depend on the money earned with homeopathy whereas scientists conducting studies on the effectiveness of homeopathy are possibly funded by pharma companies or lobby associations. These factors were not manipulated extensively within the studies, since the evaluation becomes more difficult and possibly subjective when more information on the sources vary on various dimensions. Hence, the sources may no longer be clearly ranked in a way that is objectively appropriate. Individuals may assign different relevance weights on each dimension, resulting in divergent rank orders. Thus, if only a single piece of information, e.g., their expertise, is provided, the dispersion of sources is clearer and can be distinguished more easily. However, since the sources are real sources, they implicitly varied on dimensions other than expertise, as well. Nevertheless, future studies could account for this and carefully consider the manipulation of source information. Further, participants should be asked to indicate their perception of the sources and, for example, rate their perceived expertise. Within my studies, I cannot completely exclude the possibility that I have attributed a certain expertise to the experts, but that this expertise does not correspond to the expertise perceived by the

participants. For example, it is possible that participants do not trust physicians and journalists and, therefore, do not acknowledge their expertise as such.

If necessary, the overuse of information throughout the studies independent of design can be met by limiting the search process – either by stating a certain number of information pieces available, by adding costs for each piece of information searched or by exposing the participants to time pressure. However, the overuse of information was an interesting result, indicating that participants did not prioritize information in such limited and pre-structured environments. Thus, regulating the amount of information search might contradict the natural search process. This should be carefully considered.

In relation to the investigation of belief change, the studies in this dissertation showed that some participants changed their beliefs after information search, whereas other did not. This varied between the topics. Reasons for this observation beyond the behavior intentions remain unclear. In future studies, the findings regarding the key determinants of belief in CAM and belief in homeopathy could be used to obtain further insights and investigate whether they can explain part of the individual differences in belief change and belief perseverance. Additionally, a follow up survey after several weeks may provide valuable insights. Based on the studies here, the stability of belief change remains unknown. Thus, future research should ask for the beliefs after a reasonable time interval to examine whether the information searched provided an enduring belief change or whether it was merely a short-term effect.

All in all, it is necessary to adjust the information boards depending on the research aim; and there are certain aspects that can be accounted for in future studies.

### **Conclusions**

Individuals must have the abilities to prioritize information and evaluate the information sources for relying on credible information as a basis for making optimal decisions and unbiased judgments as well as the avoidance of irrational beliefs. This is highly

relevant for the life of an individual but also the society as a whole. Preventing and overcoming crises requires that citizens have these abilities and the motivation to behave in accordance. The studies presented in the articles of this dissertation investigated information search in different environments and introduced a modified paradigm – information boards with an integrated active search for source information. This innovative paradigm offers the possibility to examine the simultaneous search of source and content information. Overall, results showed that individuals had an awareness of the sources' relevance. Nevertheless, they were either unable or unwilling to use this information consistently since the constant prioritization of the most relevant information and application of strategies limiting the information search caused difficulties. Context factors, i.e., the environment and individual differences, influence the search of information and thus, subsequent processes such as decision making and belief change. It can be concluded that when information is easily accessible, individuals tend to overuse information and also consider less relevant information, which might distract them from the most relevant information and its implications for optimal decisions, judgments, and sound beliefs. Especially in times of ever-evolving technologies, we need to be aware of this and aid individuals from an early age to become competent in searching and evaluating information. The findings provide indicators for designing interventions and future research. The newly introduced modified information boards provide a novel paradigm to conduct further studies in this context.

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# Appendix

## **Article 2**

Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations

Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations

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#### **Author Note**

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### **Abstract**

Many people use homeopathy to address health issues despite its scientifically confirmed uselessness beyond placebo effects. How do people search information in this context? Does the presentation of an argument change prior beliefs? In an experimental study ( $N = 201$ ), participants searched one of four arguments varying in terms of source expertise (medical expert vs. medical layperson) and direction (pro vs. con) related to a controversially discussed topic in the context of homeopathy. Arguments from expert sources were prioritized and searched most. Participants who intend to take homeopathy were less likely to search expert arguments than participants without this intention. Argument direction had no effect. In addition to information search, participants judged their agreement with the topic prior to and after being exposed to the argument. Those beliefs did not change significantly due to argument exposure. However, future intake intention affected belief change – participants intending to take homeopathic remedies in the future changed their beliefs slightly.

*Keywords:* information search; arguments; belief change; homeopathy

## **Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations**

In recent years, many topics have been discussed controversially in public, e.g., climate change, vaccinations, and complementary and alternative medicine (CAM). From a scientific point of view, those topics are largely resolved (Sinatra & Seyranian, 2015). Nevertheless, the topics remain controversial among the general population (Pew Research Center, 2015). Thus, individuals are confronted with scientific and non-scientific information that either confirms or disconfirms their prior beliefs. Some individuals are prone to prioritize and place greater trust in personal beliefs and pseudoscientific ideologies compared to empirical evidence (e.g., Lewandowsky et al., 2012; Schmaltz & Lilienfeld, 2014). This can yield different consequences such as a decline in vaccination rates, development of paranormal explanations about the world, as well as heightened prevalence of belief in and use of complementary and alternative medicine (CAM) such as homeopathy (Barberia et al., 2013; Barberia et al., 2018; Cook & Lewandowsky, 2016; Hornsey & Fielding, 2017; Matute et al., 2015). Generally, the misinterpretation of empirical evidence and denial of scientific findings can lead to undesired effects, including societal inaction, substantial social and economic costs, and heightened health risks for the individual as well as public health (Kerr & Wilson, 2018). Thus, especially in times when much information contrary to scientific knowledge is circulating, it is important to investigate how people search information in relation to those topics, whether the search process is influenced by individual beliefs and related behavioral intentions, and whether new information can change prior beliefs.

### **Information Search**

Informed health decisions require the ability to “obtain, process, understand, and communicate about health-related information” (Berkman et al., 2010). To avoid inferior (health) decisions and faulty beliefs, it is important to have information based on the best available evidence. There are different factors that can influence which information is



searched and assessed in greater detail, e.g., argument direction (i.e., pro vs. con), prior beliefs, behavioral intentions, and source expertise.

Due to the vast amount of accessible information and limited information processing time and capacity, individuals must rely on heuristics to evaluate new information and evidence (Cook & Lewandowsky, 2016). Heuristics are prone to bias – for example, people tend to favor information that confirms existing beliefs and ignore dissonant information (Festinger, 1957; Petty & Cacioppo, 1979). Information valence – i.e., whether it is a pro or contra argument for the topic at hand – determines whether the information confirms or contradicts prior beliefs and, subsequently, how the individual deals with that information. When people hold strong beliefs, especially, they strive to protect them by ignoring relevant yet belief dissonant information. In a meta-analysis concerning the relationship of cognitive dissonance and confirmatory information search, belief strength was one of the most important moderators (e.g., Freedman & Sears, 1965; Frey, 1986; Hart et al., 2009) – that is, individuals with a stronger opinion were more likely to focus on information confirming their beliefs. Thus, information search can be biased and selective (Hornsey & Fielding, 2017), even in the context of health information (Meppelink et al., 2019). Additionally, beliefs determine intentions and actual behavior (Ajzen, 1985, 1991; Fishbein & Ajzen, 1975). According to the theory of reasoned action (Fishbein & Ajzen, 1975) and the theory of planned behavior (Ajzen, 1985, 1991), “a person's intention to perform (or not to perform) a behavior is the immediate determinant of that action” (Ajzen, 1985). Thus, in relation to the health context, asking people if they intend to use certain remedies in the future is a strong indicator for the corresponding behavior. This intention, based on beliefs, can influence the search process. However, despite the proneness for biases, there are also helpful heuristics and search strategies such as the prioritization of experts. Generally, not only scientific information but also other information with which individuals are confronted come from others (Collins et al., 2018). Hence, it is often necessary to judge not only the validity of the

information but also the sources' credibility (Barzilai et al., 2020; Collins et al., 2018; Hendriks et al., 2015; König & Jucks, 2019; Pornpitakpan, 2004; Rowley et al., 2015). Especially when sources contradict each other (Bråten et al., 2011), individuals must consider and evaluate source information to examine their credibility (Braasch et al., 2013; Bråten et al., 2017; Stadtler & Bromme, 2014). Expertise is the most important characteristic associated with credible sources (Birnbaum & Stegner, 1979; Hovland & Weiss, 1951; McGinnies & Ward, 1980; O'Keefe, 2015; Wathen & Burkell, 2002) and reflects "whether the communicator can know the truth" (Martins et al., 2018). An expert source is expected to be competent due to the assumed experience and knowledge regarding the relevant topic (Birnbaum & Stegner, 1979; Hovland & Weiss, 1951). Laypeople appear to be able to evaluate and identify relevant expertise (Birnbaum et al., 1976; Bromme & Thomm, 2016) – for example, by utilizing assumptions (e.g., stereotypes), labels (e.g., Dr. or Professor), and reputations (Wathen & Burkell, 2002). Nevertheless, even when individuals correctly identified the expert source, they sometimes had difficulty prioritizing expert information in decision making – other information from less reliable sources is also considered (Aßmann et al., 2022). Generally, people base their decisions and judgments on information (Einhorn & Hogarth, 1981) provided by one or more sources (Birnbaum & Stegner, 1979; Birnbaum et al., 1976). That information is then combined to make an overall evaluation or integrated judgment (Birnbaum & Stegner, 1979; Birnbaum et al., 1976). When individuals find it difficult to decide whether a belief should be retained or changed, they often consider the information's source and its credibility (Collins et al., 2018; Knauff, 2018). Information provided by an expert source, for example, influences individuals' beliefs more than information provided by a non-expert source (Kerr & Wilson, 2018).

### **Beliefs and Belief Change**

Preexisting beliefs are often used to evaluate new information (Braasch et al., 2014; Kube & Rozenkrantz, 2021). The evaluation of new information is thus not only determined

by the source's expertise and content credibility but also by the conformity of the content with the individual's own opinion (Harris et al., 2016; Hornsey & Fielding, 2017) – that is, whether the information supports or contradicts prior beliefs (Festinger, 1957). However, whereas prior beliefs influence how individuals search new information, new information may also influence prior beliefs. Extensive research on belief perseverance or confirmation bias showed that people prefer to maintain their beliefs and often have difficulty revising their beliefs especially when they were confronted with mixed information (e.g., Festinger, 1957; Klayman, 1995; Kunda, 1990; Ross et al., 1975). However, there is also recent research demonstrating that people can actually change their beliefs due to new information, especially when this is clear (Anglin, 2019; see also Cohen et al., 2000). The studies showed that “participants shifted their beliefs in response to the evidence, even when it challenged their views” on controversial topics (Anglin, 2019).

### **Overview of the Present Study**

This study attempts to investigate a single information search and belief change in a concrete, applied context. This context is a topic that is controversial in the general population but not among experts, precisely homeopathy. For providing a realistic scenario, the information presented to the participants are real arguments differing in terms of direction and source expertise that can be found online. We sought to examine which information individuals prioritize. We assume that all participants prioritize an argument from an expert source over the arguments from laypersons. Further, we wanted to explore whether there are any differences in the prioritization of information between homeopathy users and non-users. Beyond examining information search, this study further investigates to what extent the presented information changes individuals' prior beliefs. Thus, the degree of belief change in response to the single piece of information, i.e., the presentation of the argument, shall be analyzed with direct measurement (cf. Anglin, 2019). We expect that the prior belief changes in response reading an argument either because participants searched an argument confirming

their prior beliefs and strengthen it or because participants searched an argument opposing their prior belief and revise it in response to the argument. Thus, agreement increases ( $T1 < T2$ ) when a pro argument was read<sup>1</sup> and decreases when a contra argument was read ( $T1 > T2$ )<sup>2</sup>. The study was preregistered. The preregistration can be found in the online supplement.

## Method

### Sample

Participants were recruited from Prolific, a platform for online subject recruitment explicitly for research purposes. Samples derived from recruiting platforms are considered to be more diverse than student samples and depict a broader population – even though they are not representative of the population (Crump et al., 2013; Paolacci & Chandler, 2014). We obtained the preregistered sample size; 201 individuals participated in the study. No data were excluded from analyses, since preregistered exclusion criteria did not apply. The sample included 91 women (45 %) and 110 (55%) men from Germany. Age ranged between 29 and 69 years ( $M = 39.43$  years,  $SD = 9.87$ ). Participants received a flat fee of £1.75 in compensation for their participation.

### Design

Two factors, source expertise (medical expert vs. medical layperson) and argument direction (pro vs. con) were varied within subjects. Those variations were combined, resulting in four arguments (e.g., medical expert + pro). The arguments were related to a question regarding the controversially discussed topic ‘effectiveness of homeopathy’.<sup>3</sup>

The first dependent variable is information search, which was measured as the argument that participants chose to read fully. They decided based on knowing the expertise of the source and the first words of the argument (see Material and Procedure). Asking

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<sup>1</sup> This is only possible if the prior belief is not the maximum of scale.

<sup>2</sup> This is only possible if the prior belief is not the minimum of scale.

<sup>3</sup> Originally, we had a second topic, the discussion about the coverage of homeopathy by health insurance companies. Due to a mistake in the material, we have no useful data for this topic. Thus, we only focus on the topic ‘effectiveness’ in this paper.

participants to choose information reveals their information preference and provides indications of unobservable thinking patterns (Willemssen & Johnson, 2011). The second dependent variable is the belief change after argument exposure. This was measured with a personal judgment.

## **Materials**

### ***Questions and Arguments***

We addressed the discussion regarding the effectiveness of homeopathy beyond placebo effects. We framed this topic with the following question: “Is homeopathy only effective due to the placebo effect?” along with arguments provided by two physicians as medical experts and two patients as medical laypersons. The arguments were embedded within a scenario implemented as realistically as possible. Participants were asked to imagine that their attention is drawn to an online newspaper article with a discussion on homeopathy that they cannot access fully because they do not have a subscription. However, they can read a preview of their choice – which is one argument out of four.<sup>4</sup> Argument direction was indicated by “Yes” and “No” at the beginning of the argument, whereas source expertise was indicated rather implicitly by stating the interviewed person’s role. The arguments are real statements that were carefully selected through pre-testing. We pretested 24 arguments related to the discussion of homeopathy’s effectiveness with 40 participants evaluating several criteria.

### ***Behavior Intentions and Beliefs***

In addition to information search, we were interested in behavior intentions and beliefs. *Future intake intention* served as an indicator of prospective use or non-use of homeopathy and was assessed with the item: “Do you intend to take homeopathic remedies in the future?”. Prior to the presentation of the scenario, participants were asked to indicate their

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<sup>4</sup> The full scenario description can be found in the online supplement. All arguments can be found in Table A in the online supplement in English and German.

personal agreement with the topic. In this case, the topic was not presented as a question but as a statement, i.e., “Homeopathic remedies are only effective due to the placebo effect.”. Participants had to judge their agreement with this statement on a scale ranging from 1 (“do not at all agree”) to 5 (“completely agree”). We refer to these judgments as their *prior beliefs*. Immediately after the presentation of the chosen argument, we asked for the same judgments. We refer to these judgments as their *posterior beliefs*.<sup>5</sup>

## Procedure

The questionnaire was conducted online using SoSci Survey (Leiner, 2019). Participants voluntarily agreed to participate in a study on information search and engagement with discourses in the field of health. Informed consent was obtained at the beginning of the study. Afterwards, participants provided demographical information and answered the behavior and attitude scales. Then, participants provided their judgment about the statement – i.e., their prior beliefs. Next, participants were presented with the newspaper scenario<sup>6</sup> as displayed in Figure 1. Participants could see the related question indicating the topic along with the arguments’ source and, as a preview of the argument, the first two words. This indicated whether the argument was pro or con. Participants were asked to decide which argument they wanted to read in full by clicking on the argument. After the decision, the full argument was presented on the next page as displayed in Figure 2. Information search was limited to this single piece of information. After the information search, participants provided their judgment about the topic statement again – i.e., their posterior beliefs. Before participants were thanked and the questionnaire was finished, they received the information that all arguments were statements from real individuals. Answering the questionnaire took approximately 5 minutes ( $M = 5.14$ ,  $SD = 1.33$ ).

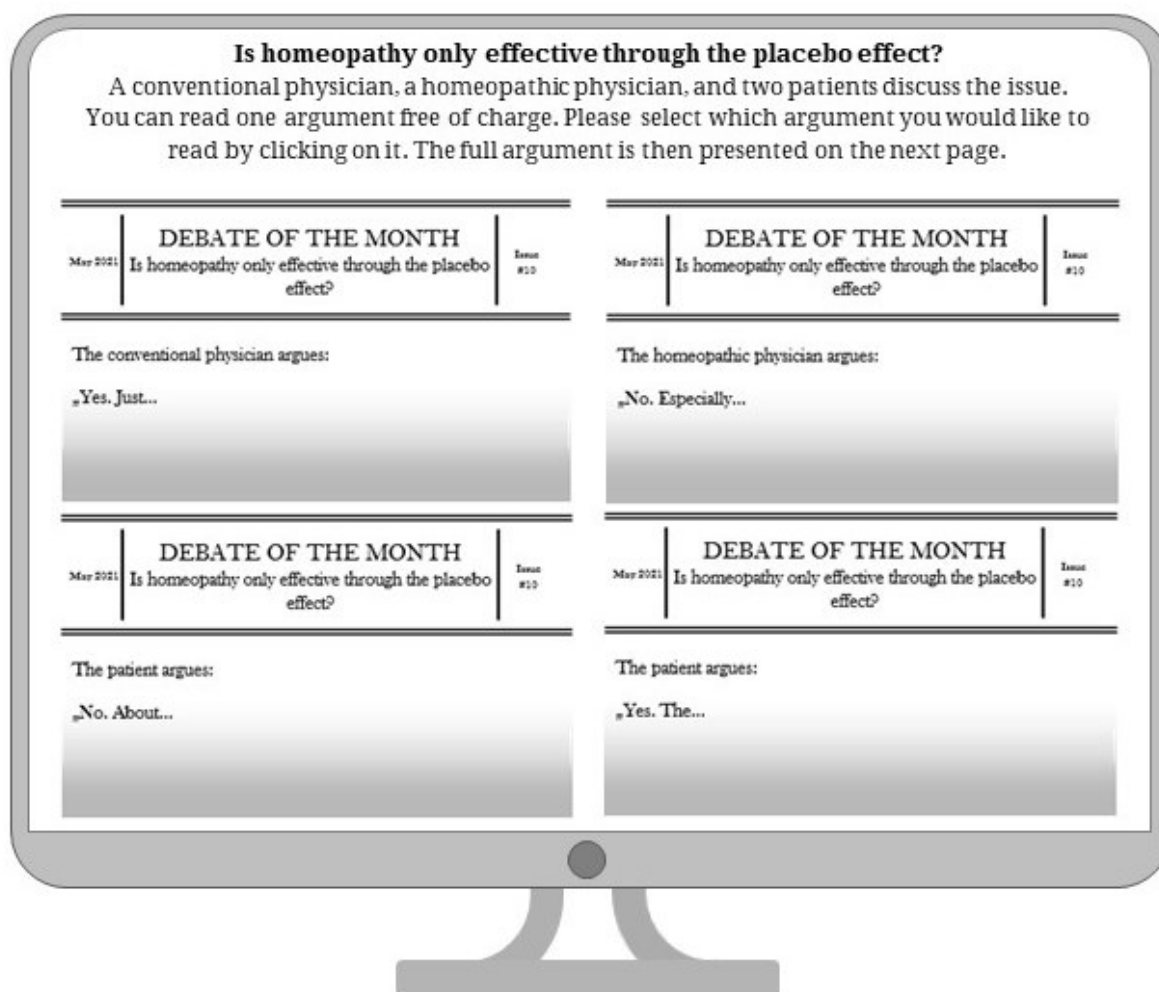
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<sup>5</sup> We assessed further variables related to behavior and attitudes that we do not address in this paper.

<sup>6</sup> We did not notice the mistake in the material until after data collection. Thus, participants were presented with both scenarios. The order of topics was randomized.

**Figure 1**

*Effectiveness Scenario as Presented to Participants*

**Figure 2**

*One of the Arguments in the Effectiveness Scenario*



The conventional physician argues:

„Yes. Just the feeling that one is being treated well leads to an improvement in symptoms. Attitudes toward the disease also improve. This is summarized under placebo and context effects. Homeopathy has nothing more to offer.”

## Results

### Information Search

#### *Hypothesis Analysis*

We hypothesized that all participants will prioritize one of the expert arguments over the arguments by laypersons. Results showed that 80 % of participants indeed searched an expert argument. Thus, they significantly prioritized arguments by experts, as the proportion was significantly higher than 50 % as indicated by a binomial test,  $p < .001$ .

#### *Exploratory Analysis*

We aimed to explore whether there are any differences in information search between homeopathy users and non-users. We differentiated homeopathy users and non-users by participants' future intake intentions. 73 participants (36 %) had the intention to take homeopathy in the future. There were differences in information search between the two groups. Table 1 displays the distribution.

**Table 1**

*Distribution of Information Search by Participants' Future Intake Intention*

participants' future intake intention	source expertise		argument direction	
	medical experts	medical laypersons	pro	con
no future intake intention	86 %	14 %	52 %	48 %
future intake intention	70 %	30 %	52 %	48 %

Note. The participants were divided in two groups by their future intake intention with participants who had no future intake intention ( $n = 128$ ) and participants who had an intake intention ( $n = 73$ ). The relative frequencies of information searched are separated by the independent variables source expertise and argument direction per group.

Participants without an intake intention focused strongly on expert arguments. They searched pro and con arguments in almost equal amounts. Participants with an intake intention also focused more on expert arguments but to a lesser degree than participants



without an intake intention; they also searched more layperson arguments than participants without intake intentions. Thus, participants with an intake intention prioritized expert arguments less strongly and layperson arguments more strongly than participants with no intake intention. Their search of pro and con arguments was quite equal, as well. Hence, the information search of participants who do intend to take homeopathy did not differ in terms of argument direction from the information search of participants who do not intend to take homeopathy.

## **Belief Change**

### *Hypothesis Analysis*

We sought to investigate whether beliefs change due to exposure to the argument. Participants were asked to judge their agreement with the topic prior to and after reading the argument searched. Low agreement reflects beliefs favoring homeopathy's effectiveness beyond placebo, whereas high agreement reflects beliefs opposing homeopathy's effectiveness beyond placebo. Overall, prior beliefs were slightly lower ( $M = 3.54$ ,  $SD = 1.41$ ) than posterior beliefs ( $M = 3.59$ ,  $SD = 1.39$ ). In general, beliefs remained stable or strengthened slightly ( $\Delta M = .05$ ,  $SD = .70$ , range: -3–4). Thus, most participants preserved their beliefs. Only forty-seven participants (23.5 %) <sup>7</sup> changed their beliefs. We expected prior beliefs to change according to the argument read. <sup>8</sup> The information search distribution was slightly skewed, with 105 participants searching a pro argument and 95 participants searching a con argument. Participants were slightly sensitive to argument direction in the case of pro arguments – if they searched a pro argument, their beliefs increased ( $M_{\text{Prior}} = 3.61$ ,  $SD_{\text{Prior}} = 1.32$ ,  $M_{\text{Post}} = 3.72$ ,  $SD_{\text{Post}} = 1.25$ ). If they searched a con argument, their beliefs remained rather stable ( $M_{\text{Prior}} = 3.47$ ,  $SD_{\text{Prior}} = 1.50$ ,  $M_{\text{Post}} = 3.44$ ,  $SD_{\text{Post}} = 1.52$ ). The mixed ANOVA with prior and post belief as within-subject variables and argument direction as a

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<sup>7</sup> The data for posterior belief of one participant is missing. Thus, this reflects the percentage related to  $N = 200$ .

<sup>8</sup> The preregistered analysis to test this hypothesis was the t-test for independent samples. However, we decided to conduct a repeated measures ANOVA to make all comparisons in a single analysis.

between-subject variable determined neither a significant effect of beliefs,  $F(1,198) = .69$ ,  $p = .406$ ,  $\eta_p^2 = .003$ , nor a significant effect of argument direction,  $F(1,198) = 1.19$ ,  $p = .278$ ,  $\eta_p^2 = .006$ . The interaction of beliefs and argument direction was also not significant,  $F(1,198) = 2.15$ ,  $p = .144$ ,  $\eta_p^2 = .01$ . Contrary our expectations, beliefs did not significantly change after being exposed to an argument. Thus, argument direction had no effect.

### ***Exploratory Analysis***

Since future intake intention influenced the information search, we additionally investigated whether it also influenced belief change. Beliefs generally varied between participants with different intake intentions. That is, participants with a future intake intention were more likely to hold the belief that homeopathy is not only effective due to the placebo effect ( $M_{\text{Prior}} = 2.19$ ,  $SD_{\text{Prior}} = 1.06$ ). In contrast, participants with no future intake intention were more likely to hold the belief that homeopathy is only effective through the placebo effect ( $M_{\text{Prior}} = 4.31$ ,  $SD_{\text{Prior}} = .91$ ). The belief change is slightly higher for those with the intention to take homeopathy in the future ( $M_{\text{Post}} = 2.42$ ,  $SD_{\text{Post}} = 1.19$ ) than for those without the intention ( $M_{\text{Post}} = 4.26$ ,  $SD_{\text{Post}} = 1.00$ ). We examined belief change using a mixed ANOVA with prior and post belief as within-subject variables and future intake intention as a between-subject variable. This indicated no significant main effect of belief,  $F(1,198) = 2.80$ ,  $p = .096$ ,  $\eta_p^2 = .014$ , but a significant main effect of future intake intention,  $F(1,198) = 197.21$ ,  $p < .001$ ,  $\eta_p^2 = .499$ , and a significant interaction of belief and future intake intention,  $F(1,198) = 8.50$ ,  $p = .004$ ,  $\eta_p^2 = .041$ . Hence, the results confirm the difference indicated by the descriptive data – participants generally differed regarding their beliefs and those with a future intake intention changed their beliefs significantly more than participants without such an intention. That is, they agreed more strongly that homeopathy is only effective due to the placebo effect after information search.

## Discussion

We investigated which information, in the form of arguments, individuals prioritize when argument direction and source expertise is varied as well as whether participants prioritize the latter particularly strongly. Differences in information search between participants with different behavioral intentions were also explored. Reliable information is highly relevant for successful judgment and decision making. Source evaluation is also important, not only for deciding how much weight is given to sources' testimonies (Levy, 2019), but also how much influence the information has on beliefs. Thus, we also investigated the degree to which participants' prior beliefs changed due to exposure to arguments either supporting or conflicting with their prior beliefs. We will first discuss information search and the consideration of source expertise before we focus on beliefs and belief change.

### Information Search

Generally, the variation of source expertise had an effect. As in previous studies, we found that participants were able to evaluate and identify relevant expertise (Birnbaum et al., 1976; Bromme & Thomm, 2016). Thus, they prioritized experts and searched an expert argument significantly more often. Interestingly, despite the fact that participants overall focused most on one of the expert arguments, there was a difference between the information search of participants who do not intend to take homeopathy and those who do intend to take homeopathy regarding source expertise. Participants with an intake intention preferred expert arguments but still searched fewer expert arguments and more arguments by laypersons than participants without an intake intention. An explanation could be that participants generally rely on different kinds of information and evidence. The main 'evidence' favoring homeopathy is solely anecdotal (Beyerstein, 2001; Čavojová & Ersoy, 2020) or results from studies that are methodologically weak (Anlauf et al., 2015; Ernst & Smith, 2018). Hence, people mainly rely on subjective references – family, friends, and colleagues reporting experiences of successful treatment – rather than empirical evidence from systematic

research. In our scenario, the laypersons were patients. It is quite reasonable to expect that they provide testimonials sharing own experiences. This might have been of particular interest to those with intake intentions, since they likely value not only empirical evidence provided by experts but also ‘anecdotal evidence’ typically provided by laypersons due to their possible previous experiences. Thus, for such individuals, personal experiences are highly informative and persuasive even if they are meaningless from a scientific point of view. As a result, when making (medical) decisions, individuals with intake intentions do not rely solely on scientific evidence but also value positive personal experiences. They might have already shared successful treatment experiences with family, friends, and colleagues, as well, in which case our finding may also be an effect of norms (Kahneman & Miller, 1986). However, in our study, 64% of participants indicated that they do not intend to take homeopathic remedies in the future. It seems that those participants already gained knowledge through correct information and mostly formed intentions following the current consensus of science due to empirical evidence. We assume that, as a result, they focused mainly on experts and prioritized expert information. A careful evaluation of information and its sources prevents the formation of questionable beliefs based on false information.

### **Beliefs and Belief Change**

In general, people are rather reluctant to question their own beliefs and try to persevere them (Festinger, 1957; Klayman, 1995; Kunda, 1990; Ross et al., 1975). Indeed, in our study only approximately 24% of participants changed their beliefs. Thus, belief perseverance was quite high for most participants. In general, it is adaptive to change beliefs if there is information that disconfirms the prior belief (Kube & Rozenkrantz, 2021) and participants did so in previous studies (e.g. Anglin, 2019; Cohen et al., 2000). However, sufficient reliable information must be available, which might not have been the case in our study. For example, Anglin (2019) presented her participants with five research summaries manipulating the direction of the findings. This kind of information is rarely part of everyday information

search. Individuals are less likely to encounter scientific studies and are not directly confronted with research findings during their information search unless they specifically search for them. Instead, it is more common for most people to search for information online when they are unfamiliar with a topic (cf. Taddicken, 2013). In this process, they are more likely to encounter individual arguments from various sources, depending on the intensity of their search. Thus, to resemble the everyday information search or confrontation with information more closely, we decided to present arguments varying in terms of source expertise and direction (pro vs. con). However, the limitation to search only for one argument was probably not sufficient to encourage belief change. Additionally, participants' consistent adherence to their beliefs might also be a form of protecting their worldview, which was presumably built on a much greater body of information – regardless of its correctness – and experiences, which could not be conquered by a single piece of new information (cf. Scharrer et al., 2021). According to Anderson's information integration model (1971), the weight of the initial opinion, and thus the strength of prior belief, together with the weight and value of new information result in belief change. In our case, for one group the strength of prior belief was possibly too high to change their belief, whereas for the other group the value of the new information led to a slight change of beliefs – as, interestingly, participants with a future intake intention changed their beliefs significantly more than participants without such an intention. Their beliefs are not grounded on evidence-based information (cf. Čavojová & Ersoy, 2020; Ernst & Smith, 2018; Galbraith et al., 2018) but rather on anecdotal evidence. However, this might be a reason why they can be challenged more easily by new information. In contrast, opponents of homeopathy based their beliefs on strong information – empirical evidence. Thus, their beliefs do not change easily, independent of the source and content of new information. This could also be an explanation for why argument direction had no effect on beliefs.

## **Conclusion**

In conclusion, our findings show that, as expected, participants are sensitive to source expertise and mainly prioritized arguments by experts. However, future intake intention influenced the extent to which participants focused on experts. Individuals with an intention to take homeopathy in the future searched arguments by laypersons more often than other participants. Thus, not only source expertise but also future intake intention appeared to affect information search. Further, most participants preserved their beliefs; the direction of the argument searched had no influence on belief change.

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## **Supplementary Material: Article 2**

Expertise is power, but not always: When source expertise influences the prioritization of information but participant behavior intentions lead to deviations

## Scenario description

„Please imagine that your attention is drawn to an article on the homepage of a major German daily newspaper in which homeopathy is being discussed. Here, four people exchange their views on two different questions and put forward different arguments. However, you cannot read the entire debate because you have not subscribed to the newspaper. Nevertheless, you can read one argument of your choice per question. This situation is illustrated on the next pages. In each case, you will see the question and information about the four people. Then you can decide which argument you want to read.”

**Table A**

*Overview of Arguments Used in The Effectiveness Scenario*

Argument combination	English Translation	German Original
expert + pro	The conventional physician argues: "Yes. Just the feeling that one is being treated well leads to an improvement in symptoms. Attitudes toward the disease also improve. This is summarized under placebo and context effects. Homeopathy has nothing more to offer."	Die schulmedizinische Ärztin argumentiert: „Ja. Alleine das Gefühl, dass man gut behandelt wird, führt zur Verbesserung der Symptome. Auch die Einstellung zur Erkrankung verbessert sich. Das fasst man unter Placebo- und Kontexteffekten zusammen. Die Homöopathie hat nicht mehr zu bieten.“
expert + con	The homeopathic physician argues: "No. Especially in patients with chronic diseases who are "out of treatment" from the point of view of conventional medicine, there are countless examples where homeopathic treatment has helped."	Der homöopathische Arzt argumentiert: „Nein. Gerade bei Patienten mit chronifizierten Erkrankungen, die aus Sicht der konventionellen Medizin „austherapiert“ sind, gibt es unzählige Beispiele, bei denen eine homöopathische Behandlung geholfen hat.“
layperson + pro	The patient argues: "Yes. The discussion about homeopathy is about an ideology that promotes elucidation instead of enlightenment. An ideology that assumes a factual placebo has efficacy beyond the placebo effect."	Der Patient argumentiert: „Ja. Bei der Diskussion um Homöopathie geht es um eine Ideologie, die Verklärung anstelle von Aufklärung fördert. Eine Ideologie, die einem faktischen Placebo eine Wirksamkeit über den Placeboeffekt hinaus unterstellt.“
layperson + con	The patient argues: "No. About 40 years ago I had an amazing experience with a treatment by a doctor who treated me with homeopathic remedies. My body's reaction to it could not have been a placebo effect or a coincidence."	Die Patientin argumentiert: „Nein. Vor ca. 40 Jahren habe ich eine verblüffende Erfahrung mit einer Behandlung durch einen Arzt gemacht, der mich mit homöopathischen Globuli behandelt hat. Die Reaktion meines Körpers darauf kann kein Placebo-Effekt und auch kein Zufall gewesen sein.“



## **Article 4**

You ask the experts – but then you don't listen to them:

Prioritization of source expertise for search start but not

for search amount

You ask the experts – but then you don't listen to them:

Prioritization of source expertise for search start but not for search amount

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### **Abstract**

Relevant and reliable information is crucial for judgments and beliefs. Due to the vast amount of information available, prioritization is needed. Information source must be considered to evaluate credibility. Thus, I investigated information search with emphasis on search start and search amount in a paradigm allowing for simultaneous search of content and source information. Additionally, I examined belief change. The study was conducted with a 2 (information tendency: affirmative vs. dismissive) x 2 (sources' expertise: expert vs. layperson) x 2 (topic: health insurance coverage vs. effectiveness of homeopathy) within design. 299 individuals participated (45.5 % women, 19–69 years). Participants prioritized source information for search start, beginning with information on source expertise. Participants did not prioritize information concerning search amount: they focused on neither expert information nor belief-confirming information. Instead, they searched almost all information provided. Depending on the topic, between 25 % and 30 % of participants changed their beliefs.

*Keywords:* information search; arguments; judgments; belief change; homeopathy

## **You ask the experts - but then you don't listen to them:**

### **Prioritization of source expertise for search start but not for search amount**

Imagine you hear a group of people discussing a topic that you have heard about before but know little about, so you would like to obtain more information. During your search, you realize that the topic is highly dependent on scientific knowledge and empirical results that exceed your own understanding – you must rely on information provided from others to form your own judgment.

In general, people must decide which information out of the vast amount of information available that they want to prioritize and which information they will ignore. These decisions are supported by consideration of the sources (Payne et al., 1988; Stenseth & Strømsø, 2019). Nevertheless, it may be difficult to find information on the information source, for example online (e.g., Bråten et al., 2017), and finding out and evaluating requires time and effort. Often, people are not willing to actively search for information on the source when the source is not provided directly (Stadtler et al., 2016). However, knowledge of the information source is key when evaluating the reliability of the information itself (Birnbaum & Stegner, 1979; Birnbaum et al., 1976; Pornpitakpan, 2004; Scharrer & Salmerón, 2016; Stadtler et al., 2016). This is especially true when one's prior knowledge of the topic at hand is insufficient to assess information validity (Bromme & Goldman, 2014; Scharrer et al., 2017) or when the information is conflicting. In such cases, the source should be considered for weighting the credibility of information (Birnbaum & Stegner, 1979; Birnbaum et al., 1976; Braasch et al., 2012; Bråten et al., 2017; Stadtler & Bromme, 2014).

### **Weighting Information**

How information is searched and evaluated is extensively investigated in judgment and decision making research for decades (e.g., Beach & Mitchell, 1978; Payne et al., 1988). In many studies, source information was provided in form of probabilistic information. Thus, the relevance of each source could be evaluated according to that. Subsequently, also the

information provided from the sources could be weighted according to the probability that the source provided correct information. Research focused on the consideration of those probabilities and derived different strategies for the process of searching information (e.g., (Gigerenzer et al., 1999; Payne et al., 1988). One such strategy is the lexicographic strategy (LEX; Payne et al., 1988) or Take The Best heuristic (TTB; Gigerenzer et al., 1999). With this strategy, individuals focus on the most relevant source (that with the highest probability of a correct prediction), consider only the information provided by this source and decide according to its prediction. This can be translated in focusing on expert advice in real-world settings, because according to research on source credibility, two factors highly influence the credibility of a source, namely its expertise and its trustworthiness (e.g., Hovland & Weiss, 1951; Pornpitakpan, 2004). Hence, the central strategy or heuristic (Chaiken, 1980) for laypersons searching information should be to prioritize experts. Normatively, experts are the best source due to their specialized deep-level knowledge and experience (Collins & Evans, 2007). Information from experts should be weighted higher than information from laypersons when evaluating their relevance. This is especially true when the individual lacks prior knowledge regarding the topic at hand to assess the validity of the information provided (Bromme & Goldman, 2014; Scharrer et al., 2017). For instance, consider the health domain. People without training in a medical field often lack the knowledge necessary to make informed health related judgments and decisions. Thus, for them, it is highly important to evaluate the sources providing the health related information. However, often, this information is not only provided by experts but also by other laypersons. Information and especially personal experiences are shared either among family and friends or online which can have an impact on the individual's subsequent judgments and decisions (Betsch et al., 2011; Haase et al., 2015).

## **Shared Information and Homeopathy**

Laypersons sharing personal experiences is highly prominent with regard to complementary and alternative medicine. Many of those treatments have lacking or even negative empirical evidence (Browne et al., 2015), as is the case for homeopathy (Galbraith et al., 2018). Homeopathy is widely popular around the world (Relton et al., 2017) despite its lacking evidence beyond the placebo effect (e.g., Kleijnen et al., 1991; Mathie et al., 2017; National Health and Medical Research Council, 2015). Nevertheless, people perceive it as a low risk alternative to traditional medical treatments, as it has few side effects. Due to its popularity, German health insurers partly cover homeopathic treatments and remedies (Jansen, 2017; Relton et al., 2017). This problem in the healthcare system is reason for a controversial debate in politics as well as the public. The debate is strongly driven by personal prior beliefs instead of reliance on empirical evidence.

## **Information and Beliefs**

Prior beliefs and new information influence each other. On the one hand, prior beliefs influence how information is searched (Bråten et al., 2017; Festinger, 1962; Roedder John et al., 1986). On the other hand, new information influences prior beliefs and might lead to belief change. According to different belief updating models (e.g., Anderson, 1981; Hogarth & Einhorn, 1992), new information is evaluated in a weighted-additive fashion with the prior belief. Thus, how strong the impact of the new information is, depends on the strength of the prior belief. When the impact is strong enough, the prior belief is updated to the posterior belief. According to dissonance theory (Festinger, 1957, 1962), information consistent with the prior beliefs is more likely to be integrated and regarded as more persuasive compared to conflicting information, regardless of the relative strength or believability of both types (Anglin, 2019; Braasch et al., 2014; Petty & Cacioppo, 1986). Since individuals often prefer to maintain their current beliefs (i.e., belief perseverance; Ross et al., 1975), information contradicting the prior beliefs is countered in two ways: To regain consistency the new

information is either rejected and ignored or the belief itself is changed (Cook & Lewandowsky, 2016; Festinger, 1957; Kienhues et al., 2020; Politzer & Carles, 2001). However, with both kinds of information – consistent and contradictory –, the prior belief is adjusted by the impact of new information when it is integrated into the underlying belief structure due to careful evaluation in terms of existing knowledge (Hogarth & Einhorn, 1992; Petty & Cacioppo, 1984).

### **Overview of the Present Study**

This study aims to investigate information search in relation to an applied context in the field of health by using information boards that allow the simultaneous search of source and content information. In previous research of judgment and decision making, the search of source information was not necessary, since it was provided by default (e.g., Bröder, 2000; Glöckner & Betsch, 2008). In the real-world, this is often not the case; rather, source information must be actively searched, which requires both additional time and cognitive resources. Thus, I used a paradigm related to the classic information boards used in judgment and decision making research but with an integrated source search (cf. Aßmann et al., 2021). This is more closely aligned with reality but still allows for a precise examination of information search. More specifically, I address the following questions: Where is the start of information search? Do participants search content and source information in similar amounts? Is search amount influenced by prior beliefs? Does the presentation of arguments lead to belief change?

Since source information is often highly important for the evaluation of the information's reliability, I expected that participants start with information on source expertise (H1). According to the mentioned strategies from judgment and decision making research (i.e., LEX, respectively TTB), I further assumed that participants search content and source information in similar amounts (H2). Participants should investigate the source information from each of the four advisors followed by a search of the content information

from the two expert advisors. Thus, I supposed that not all pieces of information are searched. In line with expectations that can be derived from dissonance theory, it is reasonable that the search amount is also influenced by the prior belief. Participants with strong prior beliefs should search less information in general (H3a) and more confirming information (H3b). Regarding belief change, I postulate that the prior belief does not change for all participants (H4). Participants might ignore the evidence and maintain their beliefs. Those participants whose belief does change, revise it according to the arguments read (H5) as can be drawn from belief updating models. If more pro arguments are read, consent with the statement will increase. If more contra arguments are read, consent with the statement will decrease. The hypotheses were preregistered – the preregistration can be found in the Appendix.

## **Method**

### **Sample**

315 participants completed the study. Participants with missing data due to technical issues were excluded as preregistered, resulting in a final sample of 299 participants<sup>1</sup>. The sample included 45.5 % women, 53.8 % men and 0.7 % diverse individuals from Germany. Age ranged between 19 and 69 years ( $M = 38.38$  years,  $SD = 9.83$ ). Most participants were recruited from Prolific and received a flat fee of £1.75 (around 2 € or \$ 2.15).

### **Design**

The study was conducted with a 2 (tendency) x 2 (expertise) x 2 (topic) within design. Argument direction (affirmative vs. dismissive) and source expertise (expert vs. layperson) were varied and combined, resulting in four arguments: expert + affirmative, expert + dismissive, layperson + affirmative, and layperson + dismissive. Arguments were related to two different topics (health insurance coverage vs. homeopathy effectiveness). Thus, there were eight arguments, four for each topic. Arguments and sources were arranged in an

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<sup>1</sup> The preregistered sample size was 300.



information board. The dependent variables were search start — measured as the first piece of information that was searched — and search amount — measured as the sum of information searched in total. Additionally, I examined belief change. Prior belief was measured as the judgment of the topic before information search, whereas posterior belief was measured as the judgment of the topic after information search.

## **Materials**

I chose two controversially discussed topics within the context of homeopathy – the coverage of homeopathy by health insurance companies and the effectiveness of homeopathy beyond placebo.

### ***Information Boards: Questions and Arguments***

I framed these topics with questions. The health insurance question was: “Should health insurance cover homeopathic remedies?”. Related arguments were provided by the Director of the Institute for Quality and Efficiency in Health Care and the German Central Association for Homeopathy as experts and two journalists as laypersons. The effectiveness question was: “Is homeopathy only effective due to the placebo effect?”. Arguments were provided by two physicians as experts and two patients as laypersons. All arguments are real statements that were carefully selected through pre-testing and can be found in Table A and Table B (Appendix).

Arguments were embedded within information boards. These information boards were computerized versions of the boards described in detail by Aßmann et al. (2021). Participants could actively search content and source information simultaneously. Figure 1 displays the information board for effectiveness. Participants could see the related question to reveal the topic along with indicators of the content of columns and rows to provide a hint for each cell.

**Figure 1***Information Board for the Topic “Effectiveness”*

“Is homeopathy only effective due to the placebo effect?”

	Contra Argument	Expertise	Pro Argument
Person D			
Person C			
Person A			
Person B			

**Continue**

Note. Columns indicated argument direction with “Pro” and “Contra” as well as source expertise. Rows indicated the sources with labels “Person A” to “Person D”. Cells contained the content and source information, which was hidden and had to be actively searched by participants. To finish the information search, participants had to click the “Continue” button.

Most studies using information boards show large effects of reading order: (western) participants tend to follow their natural reading order and start at the top-left box (Willemsen & Johnson, 2011). Thus, it is essential to counterbalance the position of different types of information across the information boards. I randomized the order of columns and rows — which randomly rotated between participants and within participants between the topics.

***Beliefs***

Prior to the presentation of the information boards, participants had to indicate their agreement with the topic. In this case, the topics were presented as statements, i.e., “Homeopathic remedies should be covered by health insurance.” and “Homeopathic remedies are only effective due to the placebo effect.”. Participants had to judge their agreement on a

scale ranging from 1 (“do not agree at all”) to 5 (“completely agree”). I refer to these judgments as their *prior beliefs*. Right after the information search, I asked for the same judgments. I refer to these judgments as their *posterior beliefs*.<sup>2</sup>

## **Procedure**

The study was programmed with lab.js (Henninger et al., 2022) in conjunction with the Multi-Attribute Decision Builder (Shevchenko, 2019) and ran online using SoSci Survey (Leiner, 2019). Participants voluntarily agreed to participate in a study on information search and engagement with discourses in the field of health. Informed consent was obtained at the beginning of the study. Afterwards, participants provided their demographical data and answered the attitude and behavior scales. Then participants provided their judgment about the health insurance statement and the effectiveness statement; their prior beliefs. Next participants were presented with the first information board. The order of topics was randomized. After having searched information, participants provided their judgment about the topics’ statement again; their posterior beliefs. They were not reminded of their prior belief. Then the second information board was presented, followed by the measurement of posterior belief. Before participants were thanked and the questionnaire was finished, they received the information that all arguments were statements from real persons or institutions and had the opportunity to give feedback or comments on the study.

Answering the questionnaire took approximately 8 minutes ( $M = 7.40$ ,  $SD = 2.36$ ).

## **Results**

### **Search Start**

I expected participants to start with information on source expertise (H1). In the health insurance scenario, 40 % of participants started their information search with source expertise, 30 % started their information search with pro arguments, and an additional 30 % started their

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<sup>2</sup> I also collected variables on attitudes and behavior, which I do not address in this paper.

information search with contra arguments. In the effectiveness scenario, 46 % started their information search with source expertise, whereas 24 % started with pro arguments and 30 % started with contra arguments. A chi-square goodness-of-fit test was used to compare the categories of search start. No expected cell frequencies were below 5. Results showed that the observed frequencies were different from an equal distribution across categories. Thus, there was a significant difference between the start of information search in both, the health insurance scenario,  $\chi^2(2) = 6.23, p = .044$ , Cohen's  $W = 0.15$ , and the effectiveness scenario,  $\chi^2(2) = 21.32, p < .001$ , Cohen's  $W = 0.27$ . Participants started their search with source expertise significantly more often than with pro or contra arguments.

### **Search Amount**

I expected participants to not search all pieces of information (H2). In both scenarios, participants searched high amounts of content and source information. In the health insurance scenario, they searched 93 % ( $SD = 18.58\%$ ) of content and 98 % ( $SD = 16.50\%$ ) of source information, whereas in the effectiveness scenario they searched 92 % ( $SD = 20.20\%$ ) of content and 98 % ( $SD = 13.85\%$ ) of source information. Thus, in general, approximately 94 % of the provided information was searched ( $M_{HI} = 11.32, SD_{HI} = 1.79; M_E = 11.32, SD_E = 1.86$ ). Thus, contrary to Hypothesis 2, participants searched almost all twelve pieces of information presented in each information board. Focusing on their individual search, I assumed that participants search content and source information in similar amounts. Since they searched almost all information in both scenarios, the amounts of content and source information search differed. 64–65 % ( $SD_{HI} = 8.01; SD_E = 8.96$ ) of participants' overall search was on content information and only 35–36 % ( $SD_{HI} = 8.01; SD_E = 8.97$ ) was on source information. These percentages match the information provided — 2/3 of the information board contained content information and 1/3 source information. According to t-Tests for dependent samples, the differences in search amounts were significant in both scenarios,  $t_{HI}(298) = 32.58, p < .001, d = 1.88$  and  $t_E(298) = 27.50, p < .001, d = 1.59$ . Hence,

in contrast to our expectations, participants did not search content and source information in similar amounts. Rather, they searched more content information, since more of this type of information was provided.

Further, I hypothesized that search amount is influenced by prior belief. That is, participants with strong prior beliefs in either direction were expected to search less information overall (H3a) and comparatively more confirming information (H3b). Since only 20 % of participants did not search all information provided, I could not analyze these questions. Thus, Hypotheses 3a and 3b were falsified due to the ceiling effect of search amount.

### **Belief Change**

I postulated that prior belief does not change for all participants (H4). As expected, only 26 % of participants changed their beliefs regarding the coverage of homeopathy by health insurance. Their agreement that health insurers should cover costs for homeopathy decreased ( $M_{\text{Prior}} = 3.36$ ,  $SD = 1.23$  and  $M_{\text{Posterior}} = 2.90$ ,  $SD = 1.16$ ). Thus, their beliefs weakened significantly,  $t(76) = 3.42$ ,  $p = .001$ ,  $d = .39$ . Regarding the effectiveness of homeopathy, 28 % of participants changed their beliefs. Participants agreed more strongly that homeopathic remedies are only effective due to the placebo effect after information search ( $M_{\text{Prior}} = 2.81$ ,  $SD = 1.25$  and  $M_{\text{Posterior}} = 3.17$ ,  $SD = 1.19$ ). Hence, their beliefs strengthened significantly,  $t(83) = -2.49$ ,  $p = .015$ ,  $d = -.27$ . In addition, I assumed that participants whose beliefs changed revised their beliefs according to the arguments read (H5). This assumption could not be tested, since most participants failed to prioritize either pro or contra arguments and searched all information instead.

## **Discussion**

I investigated the information search in relation to an applied context in the field of health. Precisely, I aimed to examine whether participants considered the source of information and prioritized certain information, e.g., information provided by experts or

information that confirms their prior beliefs. Thus, I confronted participants with information boards in which it is possible to search source and content information simultaneously.

Additionally, I examined whether participants' prior beliefs change following exposure to information. I will first discuss participants' information search.

### **Information Search & (Non-) Prioritization of Experts**

Participants prioritized source information at the beginning of their search. They primarily started with information on source expertise. Thus, they seemed to be aware that it is important to know something about the source of information to be able to evaluate the information provided. However, they did not use the source information to then search only specifically the information of the experts and terminate information search right after. Instead, 80% of participants searched all information provided in the information boards. I expected that participants prioritize information provided by experts. As a result, they should have used a strategy to limit their search (cf. LEX, respectively TTB; Gigerenzer et al., 1999; Payne et al., 1988), which consequently means that the amounts of source and content information would have been equal, with four pieces on source expertise and four on information content (i.e., the pro and contra arguments provided by experts). In our case, the amounts of source and content information differed and equaled the information provided. Since only 1/3 of the information board contained source information and 2/3 contained content information, participants did not prioritize and instead searched the whole matrix. Thus, their search amounts mirrored the distribution in the information board with more content information. Another strategy that I hypothesized was confirmatory search (cf. Festinger, 1957, 1962). I assumed that participants would tend to search for information confirming their prior beliefs. Contrary to expectations, participants with strong prior beliefs in either direction did not prioritize confirming information, since they searched almost the whole information boards. Thus, results show a prioritization in relation to the search start but no prioritization in relation to the search amount. This might be a result of our design — in

the highly pre-structured environment, it is not costly in terms of time nor cognitive capacity to search for information (Ettlin et al., 2015). This is different in the real world. On the one hand, an extensive information search there is very time consuming and requires substantial cognitive resources. Thus, it is necessary to adapt to the environment and use strategies for reducing the effort (Gigerenzer, 2008; Payne et al., 1988, 1993) and prioritize certain information. On the other hand, it becomes easier to get information. Especially on social media, one is confronted with much information which is not that costly so prioritization is not necessarily needed. Therefore, it is interesting that even within this paradigm, individuals failed to prioritize and acquired every information possible since it was easy and readily available. This can have implications for judgments and beliefs, as individuals might not differentiate which information should be used for belief updating or on what basis their judgments are formed. However, in future studies with this paradigm, participants should be confronted with time pressure or information costs to force a prioritization during information search and compare the information search processes. Nevertheless, results indicate that the source of information was considered even if it had to be actively searched and was not already provided by default as in previous studies from judgment and decision making research (e.g., Bröder, 2000; Glöckner & Betsch, 2008).

### **Overuse of Information and Beliefs**

I found an overuse of information. When people search information in the real world, they are typically confronted with wealth of information from different sources. This often results in overload (Bawden & Robinson, 2020; Schmitt et al., 2018) and inconsistencies due to lacking cognitive capacities (Miller, 1956; Simon, 1979) and biases (Kahneman, 2011). Thus, people need to prioritize information. In the present study, participants investigated nearly the whole information board and generally did not prioritize. Such an overuse of information can have different consequences. In a decision making context, for example, people deviated from adaptive behavior, which led to a decrease in decision accuracy

(Aßmann et al., 2022). In this study, participants searched information in order to make an informed judgment afterwards. They could search as much information as they liked and as often as they wished. Thus, information could directly conflict with each other. Since most participants searched all information provided, they were confronted with contradicting information before providing a second judgment concerning the topic. Most participants did not change their beliefs after information search. Thus, their belief perseverance might be the result of an overuse of information. The contradictory information might have compensated each other in the weighted-additive belief updating process (cf. (Anderson, 1981; Hogarth & Einhorn, 1992) and thus, participants maintained their prior belief.

### **Conclusion**

In general, the modified information boards provided the opportunity to investigate search behavior in relation to content and source information simultaneously in a very precise manner. Participants considered the source of information even when they had to actively search it, since it was not given by default. They even prioritized information on the source in terms of the search start. However, participants did not prioritize in relation to search amount – they overused information by searching the whole matrix and not focusing on expert- or belief-confirming information. Further, slightly more than a quarter to one third of participants changed their beliefs. The other participants persevered their beliefs.



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## **Supplementary Material: Article 4**

You ask the experts – but then you don't listen to them:

Prioritization of source expertise for search start but not

for search amount



**Table A***Overview of Arguments Used for the Topic "Health Insurance Coverage"*

Argument combination	English Translation	German Original
layperson + dismissive	The journalist argues: "No. Health insurers should reconsider to what extent the financial support for ineffective remedies is a reasonable procedure. After all, the general public pays for it."	Der Journalist argumentiert: „Nein. Die Krankenkassen sollten überdenken, inwiefern die finanzielle Unterstützung für wirkungsfreie Arzneimittel eine sinnvolle Maßnahme ist. Schließlich zahlt die Allgemeinheit dafür.“
layperson + affirmative	The journalist argues: "Yes. Single health insurance companies pay for these remedies voluntarily. That should remain the case. Because anyone who doesn't want to rely solely on conventional medicine should have the opportunity of being reimbursed for it."	Die Redakteurin argumentiert: „Ja. Einzelne Kassen bezahlen diese Medikamente freiwillig. Das sollte auch so bleiben. Denn wer nicht nur auf die Schulmedizin setzen will, sollte die Möglichkeit haben, die Kosten dafür erstattet zu bekommen.“
expert + dismissive	The head of the Institute for Quality and Efficiency in Health Care argues: "No. The statutory health insurance companies highly value scientific evidence regarding the effectiveness of medical methods and medicines. With homeopathy, however, services are financed from insureds' money that have in no way provided proof of efficacy simply for reasons of competition."	Der Leiter des Instituts für Qualität und Wirtschaftlichkeit im Gesundheitswesen argumentiert: „Nein. Die gesetzlichen Krankenkassen legen größten Wert auf wissenschaftliche Evidenz bei der Wirksamkeit von medizinischen Methoden und Medikamenten. Mit der Homöopathie werden aus Wettbewerbsgründen jedoch Leistungen aus Versichertengeldern finanziert, die in keiner Weise einen Wirksamkeitsnachweis geliefert haben.“
expert + affirmative	The representative of the German Central Association of Homeopathic Physicians argues: "Yes. According to a survey, more than 70 percent of respondents find it important to very important that health insurance companies also reimburse their insureds for selected services from the field of homeopathic medicine."	Der Deutsche Zentralverein homöopathischer Ärzte argumentiert: „Ja. Laut einer Umfrage finden es über 70 Prozent der Befragten wichtig bis sehr wichtig, dass Krankenkassen ihren Versicherten auch die Kosten für ausgewählte Leistungen aus dem Bereich der homöopathischen Medizin erstatten.“

**Table B***Overview of Arguments Used for the Topic "Effectiveness of Homeopathy"*

Argument combination	English Translation	German Original
layperson + dismissive	The patient argues: "No. About 40 years ago I had an amazing experience with a treatment by a doctor who treated me with homeopathic remedies. My body's reaction to it could not have been a placebo effect or a coincidence."	Die Patientin argumentiert: „Nein. Vor ca. 40 Jahren habe ich eine verblüffende Erfahrung mit einer Behandlung durch einen Arzt gemacht, der mich mit homöopathischen Globuli behandelt hat. Die Reaktion meines Körpers darauf kann kein Placebo-Effekt und auch kein Zufall gewesen sein.“
layperson + affirmative	The patient argues: "Yes. The discussion about homeopathy is about an ideology that promotes transfiguration instead of education. An ideology that assumes a factual placebo has efficacy beyond the placebo effect."	Der Patient argumentiert: „Ja. Bei der Diskussion um Homöopathie geht es um eine Ideologie, die Verklärung anstelle von Aufklärung fördert. Eine Ideologie, die einem faktischen Placebo eine Wirksamkeit über den Placeboeffekt hinaus unterstellt.“
expert + dismissive	The homeopathic physician argues:  "No. Especially in patients with chronic diseases who are "out of treatment" from the point of view of conventional medicine, there are countless examples where homeopathic treatment has helped."	Der homöopathische Arzt argumentiert:  „Nein. Gerade bei Patienten mit chronifizierten Erkrankungen, die aus Sicht der konventionellen Medizin „austherapiert“ sind, gibt es unzählige Beispiele, bei denen eine homöopathische Behandlung geholfen hat.“
expert + affirmative	The conventional physician argues:  "Yes. Just the feeling that one is being treated well leads to an improvement of symptoms. Attitudes toward the disease also improve. This is summarized under placebo and context effects. Homeopathy has nothing more to offer."	Die schulmedizinische Ärztin argumentiert:  „Ja. Alleine das Gefühl, dass man gut behandelt wird, führt zur Verbesserung der Symptome. Auch die Einstellung zur Erkrankung verbessert sich. Das fasst man unter Placebo- und Kontexteffekten zusammen. Die Homöopathie hat nicht mehr zu bieten.“